CS101: Problem Solving through C Programming

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C Language Introduction I

✓ C is a procedural programming language.

✓ It was initially developed by Dennis Ritchie in the year 1972.

✓ It was mainly developed as a system programming language to write an operating system.

✓ The main features of C language include low-level access to memory, a simple set of keywords, and clean style, these features make C language suitable for system programmings like an operating system or compiler development.

✓ Many later languages have borrowed syntax/features directly or indirectly from C language.

C Language Introduction II

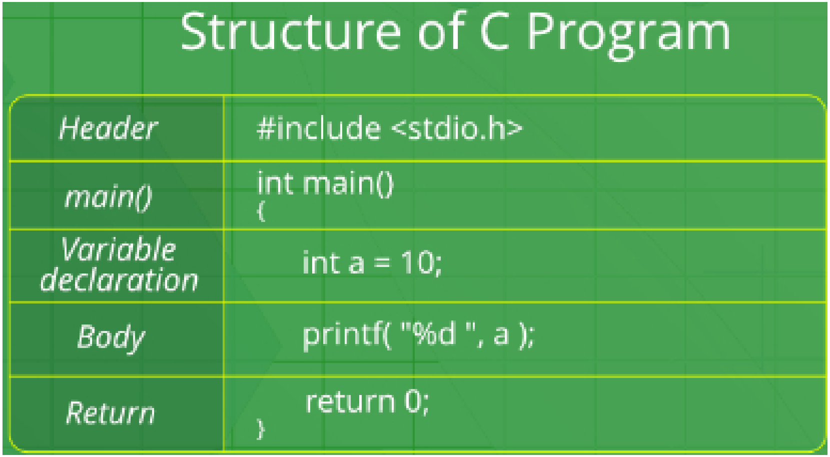
✓ Like syntax of Java, PHP, JavaScript, and many other languages are mainly based on C language.

```c
#include <stdio.h>
int main(void)
{
        /* my first program in C */
        printf("Hello, World !");
        return 0;
}
```

C Language Introduction III

```c
#include<stdio.h> //include information about standard library
main(void) //define a Junction named main that receives no
    argument values statements oj main are enclosed in braces
{
    printf("hello, world\n"); //main calls library function printf
     to print this sequence of characters; \n represents the
    newline character
}
```

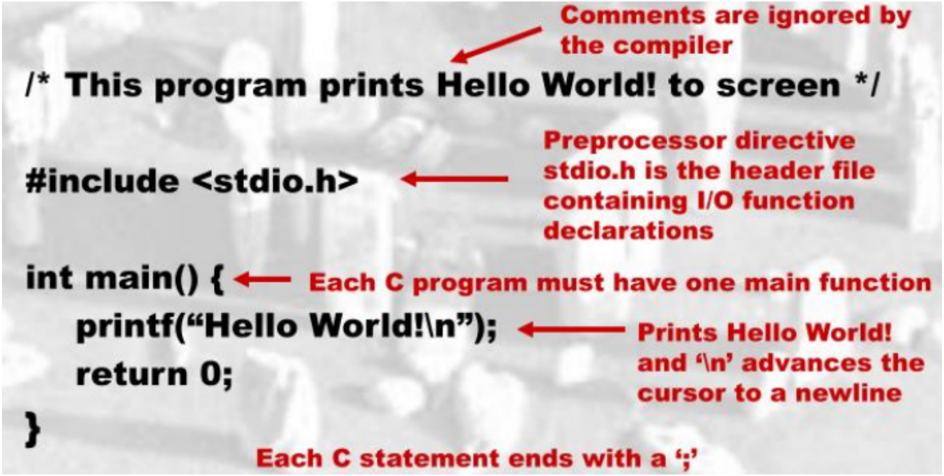
C Language Introduction IV



Structure of C Program

Header	`#include <stdio.h>`
main()	`int main()` `{`
Variable declaration	`int a = 10;`
Body	`printf( "%d ", a );`
Return	`return 0;` `}`

C Language Introduction V



```
/* This program prints Hello World! to screen */

#include <stdio.h>

int main() {
    printf(“Hello World!\n”);
    return 0;
}
```

Comments are ignored by the compiler
Preprocessor directive stdio.h is the header file containing I/O function declarations
Each C program must have one main function
Prints Hello World! and ‘\n’ advances the cursor to a newline
Each C statement ends with a ‘;’

The components of the above structure are:

C Language Introduction VI

1. Header Files Inclusion: The first and foremost component is the inclusion of the Header files in a C program.

   ✓ A header file is a file with extension .h which contains C function declarations and macro definitions to be shared between several source files.

   Some of C Header files:

   - stddef.h – Defines several useful types and macros.
   - stdint.h – Defines exact width integer types.
   - stdio.h – Defines core input and output functions
   - stdlib.h – Defines numeric conversion functions, pseudo-random network generator, memory allocation
   - string.h – Defines string handling functions

C Language Introduction VII

- math.h – Defines common mathematical functions

Syntax to include a header file in C:

```c
#include
```

2. Main Method Declaration: The next part of a C program is to declare the main(void) function. The syntax to declare the main function is: Syntax to Declare main method:

```c
int main(void)
{

}
```

C Language Introduction VIII

3. Variable Declaration: The next part of any C program is the variable declaration. It refers to the variables that are to be used in the function. Please note that in the C program, no variable can be used without being declared. Also in a C program, the variables are to be declared before any operation in the function.

   Example:

```
int main(void)
{
        int a;
    .
    .
}
```

C Language Introduction IX

4. Body: Body of a function in C program, refers to the operations that are performed in the functions. It can be anything like manipulations, searching, sorting, printing, etc.

   Example:

```c
int main(void)
{
        int a;
        printf("%d", a);
    .
    .
}
```

C Language Introduction X

5. Return Statement: The last part in any C program is the return statement. The return statement refers to the returning of the values from a function. This return statement and return value depend upon the return type of the function. For example, if the return type is void, then there will be no return statement. In any other case, there will be a return statement and the return value will be of the type of the specified return type. Example:

C Language Introduction XI

```c
#include <stdio.h>
int main(void)
{
        printf("Hello, World !");
        return 0;
}
```

C Language Introduction XII

Let us analyze the program line by line.

Line 1: [#include <stdio.h>]:

✓ In a C program, all lines that start with # are processed by preprocessor which is a program invoked by the compiler.

✓ In a very basic term, preprocessor takes a C program and produces another C program.

✓ The produced program has no lines starting with #, all such lines are processed by the preprocessor.

✓ In the above example, preprocessor copies the preprocessed code of stdio.h to our file.

C Language Introduction XIII

The .h files are called header files in C. These header files generally contain declaration of functions. We need stdio.h for the function printf() used in the program.

C Language Introduction XIV

Line 2 [int main(void)]:

✓ There must to be starting point from where execution of compiled C program begins.

✓ In C, the execution typically begins with first line of main(void).

✓ The void written in brackets indicates that the main doesn't take any parameter.

✓ main(void) can be written to take parameters also.

✓ The int written before main indicates return type of main(void).

✓ The value returned by main indicates status of program termination.

C Language Introduction XV

Line 3 and 6: [{ and }]:

✓ In C language, a pair of curly brackets define a scope and mainly used in functions and control statements like if, else, loops.

✓ All functions must start and end with curly brackets.

C Language Introduction XVI

Line 4 [printf("Hello, World !");]:

✓ printf() is a standard library function to print something on standard output.

✓ The semicolon at the end of printf indicates line termination.

✓ In C, semicolon is always used to indicate end of statement.

C Language Introduction XVII

Line 5 [return 0;]:

✓ The return statement returns the value from main(void).

✓ The returned value may be used by operating system to know termination status of your program.

✓ The value 0 typically means successful termination.

C Language Introduction XVIII

✓ The compilation is a process of converting the source code into object code. It is done with the help of the compiler. The compiler checks the source code for the syntactical or structural errors, and if the source code is error-free, then it generates the object code.

✓ The c compilation process converts the source code taken as input into the object code or machine code. The compilation process can be divided into four steps, i.e., Pre-processing, Compiling, Assembling, and Linking.

✓ The preprocessor takes the source code as an input, and it removes all the comments from the source code. The preprocessor takes the preprocessor directive and interprets it. For example, if <stdio.h>, the

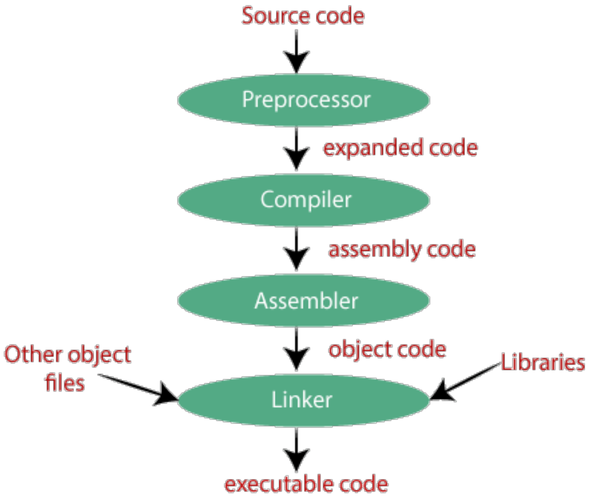
C Language Introduction XIX

directive is available in the program, then the preprocessor interprets the directive and replace this directive with the content of the 'stdio.h' file.

✓ The following are the phases through which our program passes before being transformed into an executable form:

1. Preprocessor
2. Compiler
3. Assembler
4. Linker

C Language Introduction XX



C Language Introduction XXI

Preprocessor:

✓ The source code is the code which is written in a text editor and the source code file is given an extension ".c".

✓ This source code is first passed to the preprocessor, and then the preprocessor expands this code.

✓ After expanding the code, the expanded code is passed to the compiler.

C Language Introduction XXII

Compiler:

✓ The code which is expanded by the preprocessor is passed to the compiler.

✓ The compiler converts this code into assembly code. Or we can say that the C compiler converts the pre-processed code into assembly code.

C Language Introduction XXIII

Assembler:

✓ The assembly code is converted into object code by using an assembler.

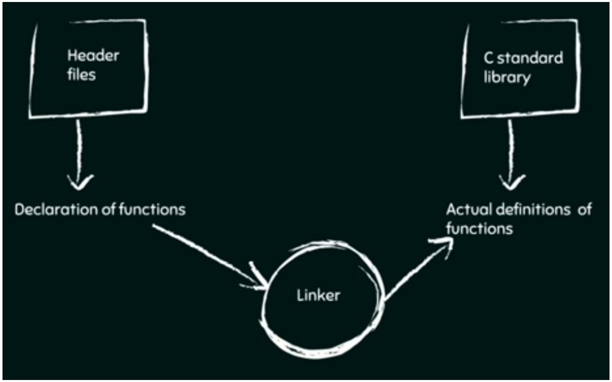
✓ The name of the object file generated by the assembler is the same as the source file.

✓ The extension of the object file in DOS is ’.obj,’ and in UNIX, the extension is ’o’.

✓ If the name of the source file is ’hello.c’, then the name of the object file would be ’hello.obj’.

C Language Introduction XXIV

Linker:



C Language Introduction XXV

✓ Mainly, all the programs written in C use library functions.

✓ These library functions are pre-compiled, and the object code of these library files is stored with '.lib' (or '.a') extension.

✓ The main working of the linker is to combine the object code of library files with the object code of our program.

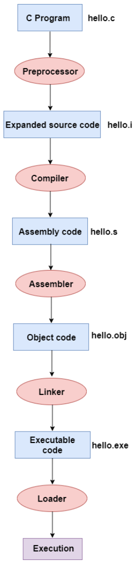
✓ Sometimes the situation arises when our program refers to the functions defined in other files; then linker plays a very important role in this.

✓ It links the object code of these files to our program.

C Language Introduction XXVI

- ✓ Therefore, we conclude that the job of the linker is to link the object code of our program with the object code of the library files and other files.
- ✓ The output of the linker is the executable file.
- ✓ In DOS, the extension of the executable file is '.exe', and in UNIX, the executable file can be named as 'a.out'.
- ✓ For example, if we are using printf() function in a program, then the linker adds its associated code in an output file.

C Language Introduction XXVII



C Language Introduction XXVIII

In the above flow diagram, the following steps are taken to execute a program:

✓ Firstly, the input file, i.e., hello.c, is passed to the preprocessor, and the preprocessor converts the source code into expanded source code.

✓ The extension of the expanded source code would be hello.i.

✓ The expanded source code is passed to the compiler, and the compiler converts this expanded source code into assembly code.

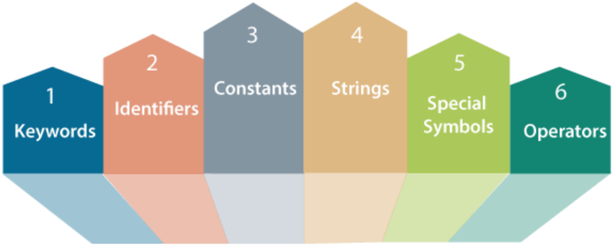
✓ The extension of the assembly code would be hello.s. This assembly code is then sent to the assembler, which converts the assembly code into object code.

C Language Introduction XXIX

- ✓ After the creation of an object code, the linker creates the executable file.
- ✓ The loader will then load the executable file for the execution.

C Tokens I

A token is the smallest element of a program that is meaningful to the compiler. Tokens can be classified as follows:



Classification of C Tokens

1. Keywords

C Tokens II

2. Identifiers
3. Constants
4. Strings
5. Special Symbols
6. Operators

Keywords:

✓ Keywords are pre-defined or reserved words in a programming language.

✓ Each keyword is meant to perform a specific function in a program.

C Tokens III

✓ Since keywords are referred names for a compiler, they can’t be used as variable names because by doing so, we are trying to assign a new meaning to the keyword which is not allowed.

✓ You cannot redefine keywords. However, you can specify the text to be substituted for keywords before compilation by using C preprocessor directives.

C Tokens IV

✓ C language supports 32 keywords which are given below:

C Tokens V

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

C Tokens VI

Identifiers:

✓ Identifiers are used as the general terminology for the naming of variables, functions and arrays.

✓ These are user-defined names consisting of an arbitrarily long sequence of letters and digits with either a letter or the underscore(_) as a first character.

✓ Identifier names must differ in spelling and case from any keywords.

✓ You cannot use keywords as identifiers; they are reserved for special use.

✓ Once declared, you can use the identifier in later program statements to refer to the associated value.

C Tokens VII

✓ A special kind of identifier, called a statement label, can be used in goto statements.

There are certain rules that should be followed while naming C identifiers:

- They must begin with a letter or underscore(_).
- They must consist of only letters, digits, or underscore. No other special character is allowed.
- It should not be a keyword.
- It must not contain white space.
- It should be up to 31 characters long as only the first 31 characters are significant.

C Tokens VIII

- main: method name.
- a: variable name.

C Tokens IX

Constants:

✓ Constants are also like normal variables. But, the only difference is, their values can not be modified by the program once they are defined.

✓ Constants refer to fixed values. They are also called literals.

✓ Constants may belong to any of the data type.

✓ const can be used to declare constant variables. Constant variables are variables which, when initialized, can't change their value. Or in other words, the value assigned to them cannot be modified further down in the program. **Syntax:**

```
const data_type var_name = var_value; (or)
const data_type *variable_name;
```

C Tokens X

Types of Constants:

1. Integer constants – Example: 0, 1, 1218, 12482
2. Real or Floating-point constants – Example: 0.0, 1203.03, 30486.184
3. Octal & Hexadecimal constants – Example: octal: $(013)_8 = (11)_{10}$, Hexadecimal: $(013)_{16} = (19)_{10}$
4. Character constants -Example: 'a', 'A', 'z'
5. String constants -Example: "BSCPMKSMK"

C Tokens XI

Strings:

✓ Strings are nothing but an array of characters ended with a null character ('\0'). This null character indicates the end of the string.

✓ Strings are always enclosed in double-quotes. Whereas, a character is enclosed in single quotes in C and C++.

Declarations for String:

```
char string[20] =
{
    'g', 'e', 'e', 'k', 's', 'f', 'o', 'r', 'g', 'e', 'e', 'k', 's
    ', '\0'
}
;
```

C Tokens XII

```c
char string[20] = "BSCPMKSMK";
char string [] = "BSCPMKSMK";
```

✓ when we declare char as "string[20]", 20 bytes of memory space is allocated for holding the string value.

✓ When we declare char as "string[]", memory space will be allocated as per the requirement during the execution of the program.

C Tokens XIII

Special Symbols:

The following special symbols are used in C having some special meaning and thus, cannot be used for some other purpose.[] () { }, ; * = #

- **Brackets[]:** Opening and closing brackets are used as array element reference. These indicate single and multidimensional subscripts.
- **Parentheses():** These special symbols are used to indicate function calls and function parameters.
- **Braces:** These opening and ending curly braces mark the start and end of a block of code containing more than one executable statement.

C Tokens XIV

- **Comma (,):** It is used to separate more than one statements like for separating parameters in function calls.
- **Colon(:):** It is an operator that essentially invokes something called an initialization list.
- **Semicolon(;):** It is known as a statement terminator. It indicates the end of one logical entity. That's why each individual statement must be ended with a semicolon.
- **Asterisk (*):** It is used to create a pointer variable.
- **Assignment operator(=):** It is used to assign values.

C Tokens XV

- **Pre-processor (#):** The preprocessor is a macro processor that is used automatically by the compiler to transform your program before actual compilation.

Operators:

✓ Operators are symbols that trigger an action when applied to C variables and other objects.

✓ The data items on which operators act upon are called operands.

✓ Depending on the number of operands that an operator can act upon, operators can be classified as follows:

C Tokens XVI

- Unary Operators: Those operators that require only a single operand to act upon are known as unary operators.For Example increment and decrement operators.
- Binary Operators: Those operators that require two operands to act upon are called binary operators. Binary operators are classified into :
  1. Arithmetic Operators
  2. Assignment Operators
  3. Relational Operators
  4. Logical Operators
  5. Unary Operators
  6. Bitwise Operators

C Tokens XVII

1. Arithmetic Operators: Arithmetic operators are used to perform arithmetic operations on variables and data.

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Modulo Operation (Remainder after division)

Example:

```
a + b; a - b;  a * b;  a / b;  a % b;
```

C Tokens XVIII

2. Assignment Operators: Assignment operators are used in C to assign values to variables.

Operator	Example	Equivalent to
=	a = b;	a = b;
+=	a += b;	a = a + b;
-=	a -= b;	a = a - b;
*=	a *= b;	a = a * b;
/=	a /= b;	a = a / b;
%=	a %= b;	a = a % b;

C Tokens XIX

3. Relational Operators: Relational operators are used to check the relationship between two operands.

```
// check is a is less than b
a < b; // Here, < operator is the relational operator. It
    checks if a is less than b or not. It returns either true
    or false.
```

Operator	Description	Example
==	Is Equal To	3 == 5 returns **False**
!=	Not Equal To	3 != 5 returns **True**
>	Greater Than	3 > 5 returns **False**
<	Less Than	3 < 5 returns **True**
>=	Greater Than or Equal To	3 >= 5 returns **False**
<=	Less Than or Equal To	3 <= 5 returns **True**

C Tokens XX

4. Logical Operators: Logical operators are used to check whether an expression is **True** or **False**. They are used in decision making.

Operator	Example	Meaning
&& (Logical AND)	expression1 && expression2	**True** only if both expression1 and expression2 are **True**
|| (Logical OR)	expression1 || expression2	**True** if either expression1 or expression2 is **True**
! (Logical NOT)	!expression	**True** if expression is **False** and vice versa

C Tokens XXI

```
int num1=12;
int num2=15;
int num3=0;
int val;
val = num1 && num2;
val = num1 || num2;
val = !num1;
val = !num3;
-------------------------
Output: ????
```

C Tokens XXII

5. Unary Operators: Unary operators are used with only one operand. For example, ++ is a unary operator that increases the value of a variable by 1. That is, ++5 will return 6.

Operator	Meaning
+	Unary plus: not necessary to use since numbers are positive without using it
-	Unary minus: inverts the sign of an expression
++	Increment operator: increments value by 1
- -	Decrement operator: decrements value by 1
!	Logical complement operator: inverts the value of a boolean

C Tokens XXIII

```
int num = 5;
// increase num by 1
++num;
// decrement num by 1
--num;
// + as unary operator
num = +5;
// - as unary operator
num = -55;
// ! as logical complement
num = !num;
------------------------
Output: ????
```

C Tokens XXIV

6. Bitwise Operators: Bitwise operators in C are used to perform operations on individual bits.

```
Bitwise complement Operation of 35
35 = 00100011 (In Binary)
~ 00100011

  ________
   11011100  = 220 (In decimal)
Here, ~ is a bitwise operator. It inverts the value of each
    bit (0 to 1 and 1 to 0).
```

C Tokens XXV

Operator	Description
&	Bitwise AND
|	Bitwise OR
^	Bitwise exclusive XOR
~	Bitwise Complement
«	Left Shift
»	Right Shift

C Tokens XXVI

```c
unsigned int a = 60;   /* 60 = 0011 1100 */
unsigned int b = 13;  /* 13 = 0000 1101 */
int c = 0;
// & bitwise AND
c = a & b;  /* 12 = 0000 1100 */
// | bitwise OR
c = a | b;  /* 61 = 0011 1101 */
// ^ bitwise XOR
c = a ^ b;  /* 49 = 0011 0001 */
// ~ bitwise complement
c = ~a; /*-61 = 1100 0011 */
// << left shift
c = a << 2; /* 240 = 1111 0000 */
```

C Tokens XXVII

```c
// >> right shift
c = a >> 2; /* 15 = 0000 1111 */
```

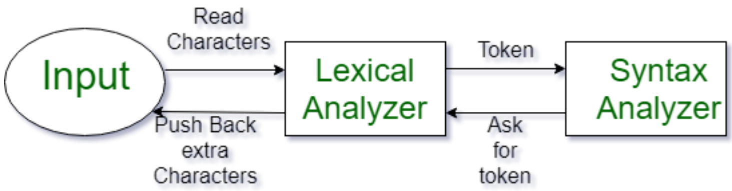
Introduction of Lexical Analyzer I

✓ Lexical Analysis is the first phase of the compiler also known as a scanner. It converts the High level input program into a sequence of Tokens.

✓ The lexical analyzer is the part of the compiler that detects the token of the program and sends it to the syntax analyzer.

✓ Token is the smallest entity of the code, it is either a keyword, identifier, constant, string literal, symbol. Examples of different types of tokens in C.

Introduction of Lexical Analyzer II



What is a token?

A lexical token is a sequence of characters that can be treated as a unit in the grammar of the programming languages.

Example of tokens:

- Type token (id, number, real, . . .)

Introduction of Lexical Analyzer III

- Punctuation tokens (IF, void, return, . . .)
- Alphabetic tokens (keywords)
- Keywords; Examples-for, while, if etc.
- Identifier; Examples-Variable name, function name, etc.
- Operators; Examples '+', '++', '-' etc.
- Separators; Examples ',' ';' etc

Example of Non-Tokens:

```
Comments, preprocessor directive, macros, blanks, tabs, newline,
    etc.
```

Introduction of Lexical Analyzer IV

Lexeme: The sequence of characters matched by a pattern to form the corresponding token or a sequence of input characters that comprises a single token is called a lexeme. eg- “float”, “abs_zero_Kelvin”, “=”, “-”, “273”, “;” .

How Lexical Analyzer functions

1. It always matches the longest character sequence.
2. Tokenization i.e. Dividing the program into valid tokens.
3. Remove white space characters.
4. Remove comments.
5. It also provides help in generating error messages by providing row numbers and column numbers.

Introduction of Lexical Analyzer V

✓ The lexical analyzer(scanner) identifies the error with the help of the automation machine and the grammar of the given language on which it is based like C, C++, and gives row number and column number of the error. Suppose we pass a statement through lexical analyzer–

```
a = b + c ;  //It will generate token sequence like this:
id= id + id;  //Where each id refers to it's variable in the
    symbol table referencing all details
```

For example, consider the program:

```
int a=5; // int a = 5 ; just for understanding.
Tokens:
|int| |a| |=| |5| |; |
```

Introduction of Lexical Analyzer VI

Another example:

```
int main()
{
      // 2 variables
      int a, b;
      a = 10;
     return 0;
}
--------------------------
Tokens:
'int'
'main'
'('
')'
```

Introduction of Lexical Analyzer VII

```
'
{
    '
    'int'
    'a'
    ','
    'b'
    '; '
    'a'
    '='
    '10'
    '; '
    'return'
    '0'
```

Introduction of Lexical Analyzer VIII

```
    '; '
    '
}
'
```

```
//How many tokens?

printf("BSCPMKSMK");
```

Introduction of Lexical Analyzer IX

```c
int main()
{
      int a = 10, b = 20;
      printf("sum is :%d",a+b);
      return 0;
}
----------
//How many tokens?
```

```c
int max(int i);
------------------
//Count number of tokens :
```

Introduction of Lexical Analyzer X

- Lexical analyzer first read int and finds it to be valid and accepts as token
- max is read by it and found to be a valid function name after reading (
- int is also a token , then again i as another token and finally ;

Answer: Total number of tokens 7:

```
|int| |max| |(| |int| |i| |)| |; |
```

```
 //Count number of tokens :

printf("i = %d, &i = %x", i, &i);
```

C Operator Precedence and Associativity I

Lvalues and Rvalues in C:

There are two kinds of expressions in C -

lvalue - Expressions that refer to a *memory location* are called "lvalue" expressions. An lvalue may appear as either the left-hand or right-hand side of an assignment operator (=).

✓ lvalue often represents as identifier.

```c
int g = 20; // valid statement
10 = 20; // invalid statement; would generate compile-time error.
```

C Operator Precedence and Associativity II

```c
// declare a an object of type 'int'
int a;
// a is an expression referring to an 'int' object as l-value
a = 1;
int b = a; // Ok, as l-value can appear on right
// Switch the operand around '=' operator
9 = a;
// Compilation error: as assignment is trying to change the  value
     of assignment operator
```

C Operator Precedence and Associativity III

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-hand side but not on the left-hand side of an assignment (=).

✓ Variables are lvalues and so they may appear on the left-hand side of an assignment.

✓ Numeric literals are rvalues and so they may not be assigned and cannot appear on the left-hand side.

C Operator Precedence and Associativity IV

```c
// declare a, b an object of type 'int'
int a = 1, b;
a + 1 = b; // Error, left expression is  is not variable(a + 1)
// declare pointer variable 'p', and 'q'
int *p, *q; // *p, *q are lvalue
*p = 1; // valid l-value assignment
// below is invalid - "p + 2" is not an l-value  p + 2 = 18;
q = p + 5; // valid - "p + 5" is an r-value
// Below is valid - dereferencing pointer expression gives an l-
    value
*(p + 2) = 18;
p = &b;
int arr[20]; // arr[12] is an lvalue; equivalent  to *(arr+12)
```

C Operator Precedence and Associativity V

```c
// Note: arr itself is also an lvalue
struct S
{
     int m;

}
;
struct S obj; // obj and obj.m are lvalues
// ptr-> is an lvalue; equivalent to (*ptr).m
// Note: ptr and *ptr are also lvalues
struct S* ptr = &obj;
```

Precedence and Associativity of Operators

✓ Precedence of operators come into picture when in an expression we need to decide which operator will be evaluated first.

✓ Operator with higher precedence will be evaluated first.

```c
int a=1;
int b=4;
int c;
//expression
c= a + b;
// Which one is correct
(c=a) + b or
c = (a+b)
```

C Operator Precedence and Associativity VII

***Lower number means higher precedence.**

Precedence	Operator	Type	Associativity
1	( ) [ ] .	Parentheses Array subscript Member selection	Left to Right
2	++ - -	Unary post-increment Unary post-decrement	Left to Right

C Operator Precedence and Associativity VIII

3	++ - - + - ! ∼ (type)	Unary pre-increment Unary pre-decrement Unary plus Unary minus Unary logical negation Unary bitwise complement Unary type cast	Right to left
4	* / %	Multiplication Division Modulus	Left to right
5	+ -	Addition Subtraction	Left to right

C Operator Precedence and Associativity IX

6	<< >> >>>	Bitwise left shift Bitwise right shift with sign extension Bitwise right shift with zero extension	Left to right
7	< <= > >=	Relational less than Relational less than or equal Relational greater than Relational greater than or equal	Left to right
8	== !=	Relational is equal to Relational is not equal to	Left to right
9	&	Bitwise AND	Left to right
10	^	Bitwise exclusive OR	Left to right
11	|	Bitwise inclusive OR	Left to right
12	&&	Logical AND	Left to right

C Operator Precedence and Associativity X

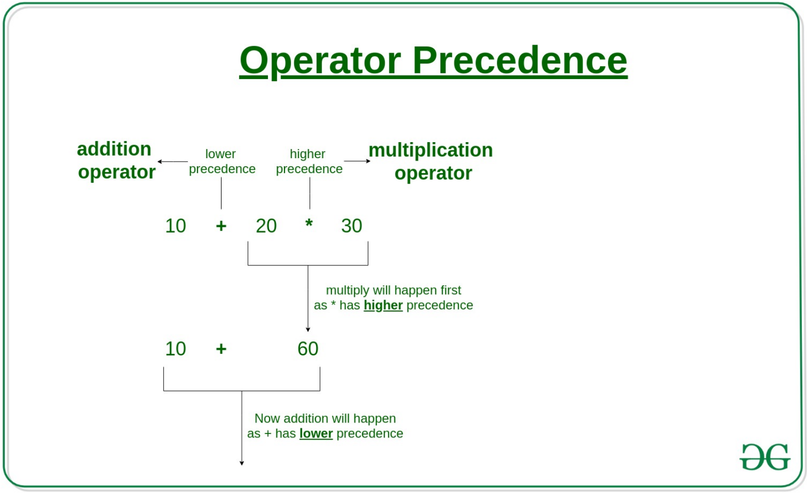
13	||	Logical OR	Left to right
14	? :	Ternary conditional	Right to left
15	= += -= *= /= %=	Assignment Addition assignment Subtraction assignment Multiplication assignment Division assignment Modulus assignment	Right to left
16	,	Comma	Left to Right

C Operator Precedence and Associativity XI

Operator precedence determines which operator is performed first in an expression with more than one operators with different precedence. For example: 10 + 20 * 30

```
2+3*5;
(2+3)*5=25 or
2+(3*5)=17
```

C Operator Precedence and Associativity XII



C Operator Precedence and Associativity XIII

```
10 + 20 * 30 is calculated as 10 + (20 * 30)
and not as (10 + 20) * 30
```

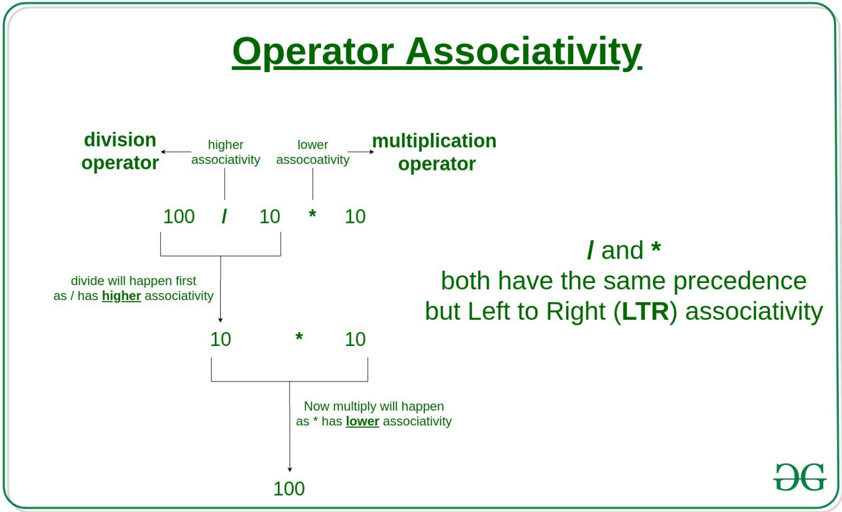
Operators Associativity is used when two operators of same precedence appear in an expression. Associativity can be either Left to Right or Right to Left.

For example: '*' and '/' have same precedence and their associativity is Left to Right.

C Operator Precedence and Associativity XIV

```
10/2*5;
//if left-to-right
(10/2)*5=25
//if right-to-left
10/(2*5)=1
```

C Operator Precedence and Associativity XV

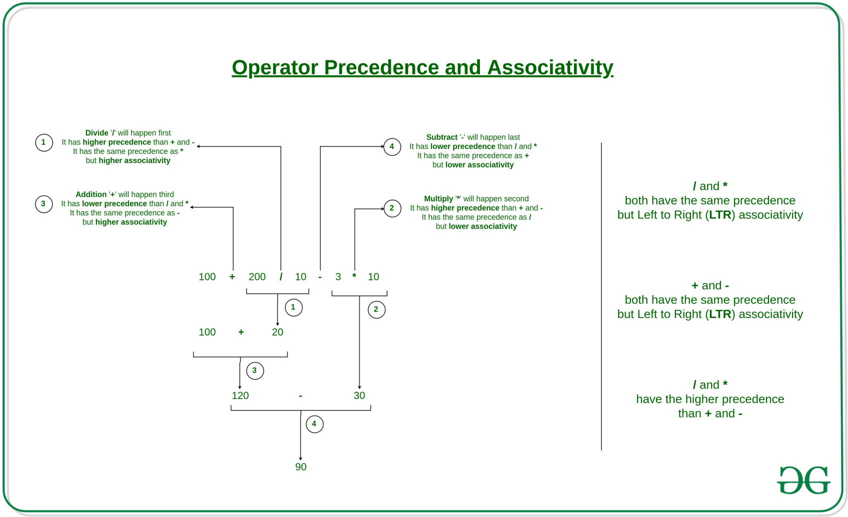

Operator Associativity
division operator
higher associativity
lower assocoativity
multiplication operator
100 / 10 * 10
divide will happen first as / has higher associativity
10 * 10
Now multiply will happen as * has lower associativity
100
/ and * both have the same precedence but Left to Right (LTR) associativity

C Operator Precedence and Associativity XVI

Operators Precedence and Associativity are two characteristics of operators that determine the evaluation order of sub-expressions in absence of brackets.

100 + 200 / 10 - 3 * 10

C Operator Precedence and Associativity XVII



Operator Precedence and Associativity

1 **Divide** '/' will happen first
It has **higher precedence** than **+** and **-**
It has the same precedence as *****
but **higher associativity**

3 **Addition** '+' will happen third
It has **lower precedence** than **/** and *****
It has the same precedence as **-**
but **higher associativity**

4 **Subtract** '-' will happen last
It has **lower precedence** than **/** and *****
It has the same precedence as **+**
but **lower associativity**

2 **Multiply** '*' will happen second
It has **higher precedence** than **+** and **-**
It has the same precedence as **/**
but **lower associativity**

/ and *****
both have the same precedence
but Left to Right (**LTR**) associativity

+ and **-**
both have the same precedence
but Left to Right (**LTR**) associativity

/ and *****
have the higher precedence
than **+** and **-**

C Operator Precedence and Associativity XVIII

1. Associativity is only used when there are two or more operators of same precedence.

   ✓ The point to note is associativity doesn't define the order in which operands of a single operator are evaluated.

   ✓ For example, consider the following program, associativity of the + operator is left to right, but it doesn't mean f1() is always called before f2().

C Operator Precedence and Associativity XIX

```c
// Associativity is not used in the below program.
// Output is compiler dependent.

#include <stdio.h>
int x = 0;
int f1()
{
        x = 5;
        return x;
}
int f2()
{
        x = 10;
```

C Operator Precedence and Associativity XX

```
        return x;
}
int main()
{
        int p = f1() + f2();
        printf("%d ", x);
        return 0;
}
```

C Operator Precedence and Associativity XXI

2. All operators with the same precedence have same associativity.

   ✓ This is necessary, otherwise, there won't be any way for the compiler to decide evaluation order of expressions which have two operators of same precedence and different associativity.

   ✓ For example + and – have the same associativity.

3. Precedence and associativity of postfix ++ and prefix ++ are different.

   ✓ Precedence of postfix ++ is more than prefix ++, their associativity is also different.

   ✓ Associativity of postfix ++ is left to right and associativity of prefix ++ is right to left.

C Operator Precedence and Associativity XXII

4. Comma has the least precedence among all operators and should be used carefully For example consider the following program, the output is 1.

```c
#include <stdio.h>
int main()
{
        int a;
        a = 1, 2, 3; // Evaluated as (a = 1), 2, 3
        printf("%d", a);
        return 0;
}
```

C Operator Precedence and Associativity XXIII

The above program fails in compilation, but the following program compiles fine and prints 1.

```c
#include<stdio.h>

int main(void)
{
        int a;
        a = 1, 2, 3;
        printf("%d", a);
        return 0;
}
```

C Operator Precedence and Associativity XXIV

```c
#include<stdio.h>

int main(void)
{
        int a;
        a = (1, 2, 3);
        printf("%d", a);
        return 0;
}
```

C Operator Precedence and Associativity XXV

In a C program, comma is used in two contexts: (1) A separator (2) An Operator.

Comma works just as a separator in PROGRAM 1 and we get compilation error in this program.

```
/* comma as an operator */
int i = (5, 10); /* 10 is assigned to i*/
int j = (f1(), f2()); /* f1() is called (evaluated) first
    followed by f2().
  The returned value of f2() is assigned to j */
```

```
/* comma as a separator */
int a = 1, b = 2;
void fun(x, y);
```

C Operator Precedence and Associativity XXVI

```c
/* Comma acts as a separator here and doesn't enforce any
    sequence.
   Therefore, either f1() or f2() can be called first */
void fun(f1(), f2());
```

```c
#include <stdio.h>
int main()
{
        int x = 10;
        int y = 15;

        printf("%d", (x, y));
        getchar();
```

C Operator Precedence and Associativity XXVII

```
        return 0;
}
```

```
#include <stdio.h>
int main()
{
        int x = 10;
        int y = (x++, ++x);
        printf("%d", y);
        getchar();
        return 0;
}
```

C Operator Precedence and Associativity XXVIII

```c
#include <stdio.h>
int main()
{
        int x = 10, y;

        // The following is equivalent
        // to y = x + 2 and x += 3,
        // with two printings
        y = (x++,
        printf("x = %d\n", x),
        ++x,
        printf("x = %d\n", x),
        x++);
```

C Operator Precedence and Associativity XXIX

```

        // Note that last expression is evaluated
        // but side effect is not updated to y
        printf("y = %d\n", y);
        printf("x = %d\n", x);

        return 0;
}
```

C Operator Precedence and Associativity XXX

5. There is no chaining of comparison operators in C
   In Python, expression like “c > b > a” is treated as “c > b and b > a”, but this type of chaining doesn’t happen in C. For example consider the following program. The output of following program is “FALSE”.

```c

#include <stdio.h>
int main()
{
        int a = 10, b = 20, c = 30;

        // (c > b > a) is treated as ((c  > b) > a),
    associativity of '>'
```

C Operator Precedence and Associativity XXXI

```
        // is left to right. Therefore the value becomes
    ((30 > 20) > 10)
        // which becomes (1 > 20)
        if (c > b > a)
       printf("TRUE");
        else
       printf("FALSE");
        return 0;
}
```

C Operator Precedence and Associativity XXXII

▶ Increment ++ and Decrement - - Operator as Prefix and Postfix

✓ Precedence of Postfix increment/Decrement operator is greater than Prefix increment/Decrement.

✓ Associativity of Postfix is also different from Prefix. Associativity of postfix operators is from left-to-right and that of prefix operators is from right-to-left.

✓ Operators with some precedence have same associativity as well.

- If you use the ++ operator as prefix like: ++var. The value of var is incremented by 1 then, it returns the value. or means first increment then assign it to another variable.

C Operator Precedence and Associativity XXXIII

- If you use the ++ operator as postfix like: var++. The original value of var is returned first then, var is incremented by 1. or means first assign it to another variable then increment.
- The - - operator works in a similar way like the ++ operator except it decreases the value by 1.

✓ you cannot use rvalue before or after increment/decrement operator.

Example:

(a+b)++; Error

++(a+b); Error.

Error: lvalue required as increment operator(compiler is expecting a variable as an increment operand but we are providing an expression

C Operator Precedence and Associativity XXXIV

(a+b) which does not have the capability to store data). Because (a+b) is rvalue. (a+b) is an expression or you can say it is value not an operator.

```c
int main()
{
      int x = 1;
      int y=0;
      x=y++;
    //  (x=y) = (x=y) +1;
      scanf("%d",&y);
      printf("%d\n%d",x,y);
     // return 0;
}
```

C Operator Precedence and Associativity XXXV

✓ Unary operator must be associated with a valid operand.

```c
int main()
{
        int a = 10, b = 5, c = 1;
        printf("%d",a+++b);
        printf("%d",a +++ b);
        printf("%d",a++ + b);
        printf("%d",a +++b);
        printf("%d",a + ++b);
        printf("%d",a+ ++b);
}
```

C Operator Precedence and Associativity XXXVI

```
a+++b;
//Valid tokens in line number 5:
|a| |++| |+| |b| |; |

//Make valid syntax for post-increment and pre-increment
// Unary operator must be associated with a valid operand.
//++ will be associated with a
a++
+
b
-------------
a++ + b;
```

C Operator Precedence and Associativity XXXVII

```c
int main()
{
        int a = 10, b = 5, c = 1, result;
        result = a-++c-++b;
        printf("%d",result);
}
```

```c
result = a-++c-++b;
//Valid tokens in line number 7:
|result|, |=|, |a|, |-|, |++|, |-|, |++| and |b|

//Make valid syntax for post-increment
```

C Operator Precedence and Associativity XXXVIII

```
int main()
{
        int a = 10, b = 15, c = 20, d=25;
        //int a = 17, b = 15, c = 20, d=25;
    if(a<= b == d > c)
    {
         printf("TRUE");
    }
    else
    {
         printf("FALSE");
    }
}
```

C Operator Precedence and Associativity XXXIX

```

|a| |<| |=| |b| |=| |=| |d| |>| |c|
OR
|a| |<=| |b| |==| |d| |>| |c|

|<=| --> Precedence 9
|==| --> Precedence 8
|>|  --> Precedence 9

((a<=b) == (d>c))
(1 == 1)
```