C Programming for Problem Solving
20CS111

Unit-I

Chapter 1: Introduction to computer System,
Chapter 2: Introduction to C Programming Languages,
Chapter 3: Operators and Expressions
Chapter 4: Managing Input & Output Operations

Chapter 1: Introduction to computer System

INTRODUCTION

COMPUTER

Today, almost all of us in the world make use of computers in one way or the other. It finds applications in various fields of engineering, medicine, commercial, research and others. Not only in these sophisticated areas, but also in our daily lives, computers have become indispensable. They are present everywhere, in all the devices that we use daily like cars, games, washing machines, microwaves etc. and in day to day computations like banking, reservations, electronic mails, internet and many more.

The word **computer** is derived from the word **compute.** Compute means to calculate. The computer was originally defined as a super fast calculator. It had the capacity to solve complex arithmetic and scientific problems at very high speed. But nowadays in addition to handling complex arithmetic computations, computers perform many other tasks like accepting, sorting, selecting, moving, comparing various types of information. They also perform arithmetic and logical operations on alphabetic, numeric and other types of information. This information provided by the user to the computer is **data.**

The information in one form which is presented to the computer is the input information or **input data.** Information in another form is presented by the computer after performing a process on it. This information is the output information or **output data.** The set of instructions given to the computer to perform various operations is called as the **computer program.** The process of converting the input data into the required output form with the help of the computer program is called as **data processing.** The computers are therefore also referred to as data processors**.** Therefore a computer can now be defined as a fast and accurate data processing system that accepts data, performs various operations on the data, has the capability to store the data and produce the results on the basis of detailed step by step instructions given to it.

The terms **hardware and software** are almost always used in connection with the computer.

- **The Hardware:**

The hardware is the machinery itself. It is made up of the physical parts or devices of the computer system like the electronic Integrated Circuits (ICs), magnetic storage media and other mechanical devices like input devices, output devices etc. All these various hardware are linked together to form an effective functional unit. The various types of hardware used in the computers, has evolved from vacuum tubes of the first generation to Ultra Large Scale Integrated Circuits of the present generation.

- **The Software:**

The computer hardware itself is not capable of doing anything on its own. It has to be given explicit instructions to perform the specific task. The computer program is the one which controls the processing activities of the computer. The computer thus functions according to the instructions written in the program. Software mainly consists of these computer programs, procedures and other documentation used in the operation of a computer system. Software is a collection of programs which utilize and enhance the capability of the hardware.

CLASSIFICATION OF COMPUTERS

Computers are broadly classified into two categories depending upon the logic used in their design as:

1. **Analog computers:**
   In analog computers, data is recognized as a continuous measurement of a physical property like voltage, speed, pressure etc. Readings on a dial or graphs are obtained as the output, ex. Voltage, temperature; pressure can be measured in this way.

2. **Digital Computers:**

   These are high speed electronic devices. These devices are programmable. They process data by way of mathematical calculations, comparison, sorting etc. They accept input and produce output as discrete signals representing high(on) or low (off) voltage state of electricity. Numbers, alphabets, symbols are all represented as a series of 1s and Os.

Digital Computers are further classified as General Purpose, Digital Computers and Special Purpose Digital Computers. General Purpose computer scan be used for any applications like accounts, payroll, data processing etc. Special purpose computers are used for a specific job like those used in automobiles, microwaves etc.

Another classification of digital computers is done on the basis of their capacity to access memory and size like:

- **Microcomputers:** Microcomputers are generally referred to as **Personal Computers (PCs).** They have smallest memory and less power. They are widely used in day to day applications like office automation, and professional applications, ex. PCAT, Pentium etc.
- **Note Book and Laptop Computers:** These are portable in nature and are battery operated. Storage devices like CDs, floppies etc. and output devices like printer scan be connected to these computers. Notebook computers are smaller in physical size than lap top computers. However, both have powerful processors, support graphics, and can accept mouse driven input.

- **Hand Held Computers:**
  These types of computers are mainly used in applications like collection of field data. They are even smaller than the note book computers.
- **Hybrid Computers:** Hybrid Computers are a combination of Analog and Digital computers. They combine the speed of analog computers and accuracy of digital computers. They are mostly used in specialized applications where the input data is in an analog form i.e. measurement. This is converted into digital form for further processing. The computers accept data from sensors and produce output using conventional input/output devices.
- **Mini Computers:** Mini computers are more powerful than the micro computers. They have higher memory capacity and more storage capacity with higher speeds. These computers are mainly used in process control systems. They are mainly used in applications like payrolls, financial accounting, Computer aided design etc. ex. VAX, PDP-11
- **Mainframe Computers:** Main frame computers are very large computers which process data at very high speeds of the order of several million instructions per second. They can be linked into a network with smaller computers, micro computers and with each other. They are typically used in large organizations, government departments etc. ex. IBM4381, CDC
- **Super Computers:** A super computer is the fastest, most powerful and most expensive computer which is used for complex tasks that require a lot of computational power. Super computers have multiple processors which process multiple instructions at the same time. This is known as **parallel processing.** These computers are widely used in very advanced applications like weather forecasting, processing geological data etc. ex. CRAY-2, NEC - 500, PARAM.

APPLICATIONS OF COMPUTERS

Today computers find widespread applications in all activities of the modern world. Some of the major application areas include:

1. **Scientific, Engineering and Research:**
   This is the major area where computers find vast applications. They are used in areas which require lot of experiments, mathematical calculations, Computer Fundamentals/10weather forecasting, and complex mathematical and engineering applications. Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) help in designing robotics, automobile manufacturing, automatic process control dev ices etc.

2. **Business:**
   Record keeping, budgets, reports, inventory, payroll, invoicing, accounts are all the areas of business and industry where computers are used to a great extent. Database management is one of the major areas where computers are used on a large scale. The areas of application here include banking, airline reservations, etc. where large amounts of data need to be updated, edited, sorted, and searched from large databases.
3. **Medicine:**
   Computerized systems are now in widespread use in monitoring patient data like, pulse rate, blood pressure etc. resulting in faster and accurate diagnosis. Modern day medical equipment are highly computerized today. Computers are also widely used in medical research.
4. **Information:**
   This is the age of information. Television, Satellite communication, Internet, networks are all based on computers.
5. **Education:**
   The use of computers in education is increasing day by day. The students develop the habit of thinking more logically and are able to formulate problem solving techniques. CDs on a variety of subjects are available to impart education. Online training programs for students are also becoming popular day by day. All the major encyclopedias, dictionaries and books are now available in the digital form and therefore are easily accessible to the student of today. Creativity in drawing, painting, designing, decoration, music etc. can be well developed with computers.
6. **Games and Entertainment:**
   Computer games are popular with children and adults alike. Computers are nowadays also used in entertainment areas like movies, sports, advertising etc.

ADVANTAGES OF COMPUTERS:

1. **Speed:**
   The speed of a computer is measured in terms of the number of instructions that it can perform or execute in a second. The speeds of computers are measured in milli seconds (10~3 sec), micro-seconds (10*6 sec), and nano-seconds (10~9sec). Computers are superfast machines and can process millions of instructions per second. Smaller computers can execute thousands of instructions per second, while the more complex machines can execute millions of instructions per second.
2. **Accuracy:**
   Computers are very accurate. They are capable of executing hundreds of instructions without any errors. They do not make mistakes in their computations. They perform each and every calculation with the same accuracy.

3. **Efficiency**
   The efficiency of computers does not decrease with age. The computer scan perform repeated tasks with the same efficiency any number of times without exhausting there selves. Even if they are instructed to execute millions of instructions, they are capable of executing them all with the same speed and efficiency without exhaustion.
4. **Storage Capability**
   Computers are capable of storing large amounts of data in their storage devices. These dev ices occupy very less space and can store millions of characters in condensed forms. These storage devices typically include floppy disks, tapes, hard disks, CDs etc, the data stored on these devices can be retrieved and reused whenever it is required in future.
5. **Versatility**
   Computers are very versatile. They are capable not only of performing complex mathematical tasks of science and engineering, but also other non-numerical operations fielding air-line reservation, electricity bills, data base management etc.

LIMITATIONS OF COMPUTERS:

Although the computers of today are highly intelligent and sophisticated they have their own limitations. The computer cannot think on its own, since it does not have its own brain. It can only do what is has been programmed to do. It can execute only those jobs that can be expressed as a finite set of instructions to achieve a specific goal. Each of the steps has to be clearly defined. The computers do not learn from previous experience nor can they arrive at a conclusion without going through all the intermediate steps. However the impact of computers on today's society in phenomenal and they are today an important part of the society.

Any system is defined as a group of integrated parts which are designed to achieve a common objective. Thus, a system is made up of more than one element or part, where each element performs a specific function and where all the elements (parts) are logically related and are controlled in such a way that the goal (purpose) of the system is achieved. Each of these units performs a specific task. However, none of them can function independently on their own. They are logically related and controlled to achieve a specific goal. When they are thus integrated they form a fully fledged **computer system.**

PROBLEM SOLVING ASPECT

Problem solving is a creative process. It is an act of defining a problem, determining the cause of the problem, identifying, prioritizing, and selecting alternatives for a solution and implementing a solution.

A problem can be solved successfully only after making an effort to understand the problem. To understand the problem, the following questions help:

1. What do we know about the problem?
2. What is the information that we have to process in order the find the solution?
3. What does the solution look like?
4. What sort of special cases exist?
5. How can we recognize that we have found the solution?

It is important to see if there are any similarities between the current problem and other problems that have already been solved. We have to be sure that the past experience does not hinder us in developing new methodology or technique for solving a problem. The important aspect to be considered in problem-solving is the ability to view a problem from a variety of angles.

PROGRAM DEVELOPMENT STEPS

Problem solving is a creative process. It is an act of defining a problem, determining the cause of the problem, identifying, prioritizing, and selecting alternatives for a solution and implementing a solution.

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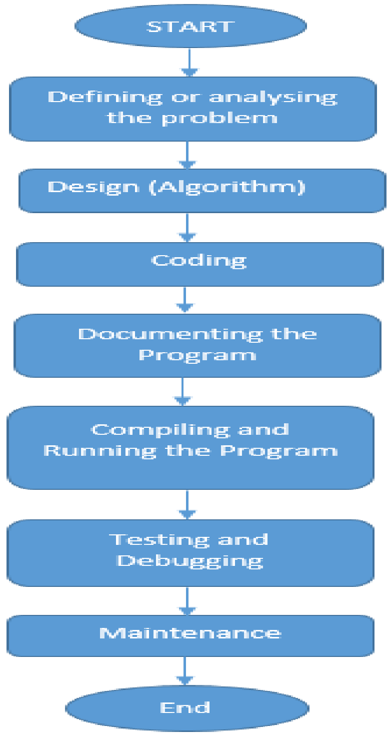
The various steps involved in Program Development are:

- Defining or Analyzing the problem
- Design (Algorithm)
- Coding
- Documenting the program
- Compiling and Running the Program
- Testing and Debugging
- Maintenance



Defining or Analyzing the Problem:

In general terms, this step entails

- Identifying the desired results (output),
- Determining what information (input) is needed to produce these results,
- Figuring out what must be done to proceed from the known data to the desired output (processing).

Although this step is described in one sentence, actually it may be the hardest part. And it is certainly the most important part! When you analyze the problem, you determine what the result will be. If you don't do this correctly, all the elegant code in the world, written and executed flawlessly, will not solve your problem.

Design (Algorithm):

To design a program means to create a detailed description, using relatively ordinary language or special diagrams of the program to be created. Typically, this description is created in stages, proceeding from simple to more complex, and consists of a number of step by-step procedures (algorithms) that combine to solve the given problem. An algorithm is like a recipe. It is a step-by-step method for solving a problem or doing a task.

Algorithms abound in programming, mathematics, and sciences and are common in everyday life as well. For example, you are making use of an algorithm when you follow a recipe to bake a cake or go through the process of using an ATM machine. Therefore, an algorithm must contain

- clear,
- unambiguous,
- step-by-step instructions.
- No step, not even the most basic and elementary, can be left out.

When we design a program, we do not completely define the algorithms all at once. As we develop the program and break down major components into smaller pieces, the algorithms for each task become more complex and detailed.

Coding

Once you have designed a suitable program to solve a given problem, you must translate that design into program code; that is, you must write statements (instructions) in a particular programming language such as C++, Visual Basic, or JavaScript etc. to put the design into a usable form.

Additional statements are included at this point to document the program. Documentation is a way to provide additional explanation in plain English (or other mother tongue) that the computer ignores but which makes it easier for others to understand the program code. Normally, a programmer provides internal and external documentation. Internal documentation exists within the code and explains it. External documentation is provided separate from the program in a user's guide or maintenance manual.

The ways that specific words and symbols are used by each language is called its *syntax* (the rules that govern the structure of the language).

Documenting the program

Documentation explains how the program works and how to use the program. Documentation can be of great value, not only to those involved in maintaining or modifying a program, but also to the programmers themselves. Details of particular programs, or particular pieces of programs, are easily forgotten or confused without suitable documentation.

Documentation comes in two forms:

- External documentation, which includes things such as reference manuals, algorithm descriptions, flowcharts, and project workbooks
- Internal documentation, which is part of the source code itself (essentially, the declarations, statements, and comments)

Compiling and Running the Program

Compilation is a process of translating a source program into machine understandable form. The compiler is system software, which does the translation after examining each instruction for its correctness. The translation results in the creation of object code.

After compilation, Linking is done if necessary. Linking is the process of putting together all the external references (other program files and functions) that are required by the program. The program is now ready for execution. During execution, the executable object code is loaded into the computer's memory and the program instructions are executed.

Testing and Debugging

Testing is the process of executing a program with the deliberate intent of finding errors. Testing is needed to check whether the expected output matches the actual output. Program should be tested with all possible input data and control conditions. Testing is done during every phase of program development. Initially, requirements can be tested for its correctness. Then, the design (algorithm, flow charts) can be tested for its exactness and efficiency.

Debugging is a process of correcting the errors. Programs may have logical errors which cannot be caught during compilation. Debugging is the process of identifying their root causes. One of the ways to ensure the correctness of the program is by printing out the intermediate results at strategic points of computation.

Some programmers use the terms "testing" and "debugging" interchangeably, but careful programmers distinguish between the two activities. Testing means detecting errors. Debugging means diagnosing and correcting the root causes. On some projects, debugging occupies as much as 50 percent of the total development time. For many programmers, debugging is the hardest part of programming because of improper documentation.

Maintenance

Programs require a continuing process of maintenance and modification to keep pace with changing requirements and implementation technologies. Maintainability and modifiability are essential characteristics of every program. Maintainability of the program is achieved by:

- Modularizing it
- Providing proper documentation for it
- Following standards and conventions (naming conventions, using symbolic constants Etc.)

Introduction to Programming Languages

What is a Programming Language?

Computer Programming is an art of making a computer to do the required operations, by means of issuing sequence of commands to it.

A programming language can be defined as a vocabulary and set of grammatical rules for instructing the computer to perform specific tasks. Each programming language has a unique set of characters, keywords and the syntax for organizing programming instructions.

The term programming languages usually refers to high-level languages, such as BASIC, C, C++,COBOL, FORTRAN, Ada, and Pascal.

Why Study Programming Languages?

The design of new programming languages and implementation methods have been evolved and improved to meet the change in requirements. Thus, there are many new languages.

The study of more than one programming language helps us:

to master different programming paradigms
to enhance the skills to state different programming concepts
to understand the significance of a particular language implementation
to compare different languages and to choose appropriate language
to improve the ability to learn new languages and to design new languages

Types and Categories of Programming Languages

Types of Programming Languages

There are two major types of programming languages:
Low Level Languages
High Level Languages

Low Level Languages

The term low level refers closeness to the way in which the machine has been built. Low level Languages are machine oriented and require extensive knowledge of computer hardware architecture and its configuration. Low Level languages are further divided in to **Machine language and Assembly language.**

(a) Machine Language

Machine Language is the only language that is directly understood by the computer. It does not need any translator program. The instructions are called machine instruction (machine code) and it is written as strings of 1's (one) and 0’s (zero). When this sequence of codes is fed in to the computer, it recognizes the code and converts it in to electrical signals.

For example, a program instruction may look like this: 1011000111101
Machine language is considered to be the first generation language. Because of its design, machine language is not an easy language to learn. It is also difficult to debug the program written in this language.

Advantage

#The program runs faster because no translation is needed. (It is already in machine understandable form)

Disadvantages

It is very difficult to write programs in machine language. The programmer has to know details of hardware to write program

It is difficult to debug the program

(b) Assembly Language

In assembly language, set of mnemonics (symbolic keywords) are used to represent machine codes. Mnemonics are usually combination of words like ADD, SUB and LOAD etc. In order to execute the programs written in assembly language, a translator program is required to translate it to the machine language. This translator program is called Assembler. Assembly language is considered to be the second-generation language.

Advantages:

The symbolic keywords are easier to code and saves time and effort

It is easier to correct errors and modify programming instructions

Assembly Language has utmost the same efficiency of execution as the machine level language, because there is one-to-one translation between assembly language program and its corresponding machine language program

Disadvantages:

#Assembly languages are machine dependent. A program written for one computer might not run in other computer.

High Level Languages

High level languages are the simple languages that use English like instructions and mathematical symbols like +, -, %, /, for its program construction. In high level languages, it is enough to know the logic and required instructions for a given problem, irrespective of the type of computer used. Compiler is a translator program which converts a program in high level language in to machine language. Higher level languages are problem-oriented languages because the instructions are suitable for solving a particular problem.

For example, COBOL (Common Business Oriented Language) is mostly suitable for business Oriented applications. There are some numerical & mathematical oriented languages like FORTRAN (Formula Translation) and BASIC (Beginners All-purpose Symbolic Instruction Code).

Advantages of High Level Languages

#High level languages are easy to learn and use

Categories of programming languages

- **Numerical Languages**

Early computer technology dates from the era just before World War 2 in the late 1930s to the early 1940s. These early machines were designed to solve numerical problems and were thought of as ELECTRONIC CALCULATORS. Numerical calculations were the dominant form of application for these early machines.

- **Business Languages**

Business data processing was an early application domain developed after numerical applications. In 1959, the US department of Defence sponsored a meeting to develop COMMON BUSINESSLANGUAGE (CBL), which would be a business-oriented language that used English as much as possible for its notation. This, in turn, led to the formation of a Short Range Committee to develop COBOL.

- **Artificial Intelligence Languages (AI)**

The first step towards the development of AI languages commenced with the evolution of IPL (Information Processing Language) by the R and Corporation. The major breakthrough occurred, When John McCarthy of MIT designed LISP (List Processing) for the IBM 704. Later, more AI languages like SNOBOL & PROLOG were designed.

- **Systems Languages**

Because of the need of efficiency, the use of assembly language held on for years in the system area long after other application domains started to use higher-level languages. Many systems programming languages such as CPL & BCPL were designed, though not widely used. The major landmark here is the development of UNIX, where high level languages also proceed to work effectively.

What makes a Good Language?

Every language has its strengths and weaknesses.

For example, FORTRAN is a particularly good language for processing numerical data, but it does not lend itself very well to organize large programs.

PASCAL is very good for writing well structuredand readable programs, but it is not as flexible as the C programming language.

C++ embodies powerful object-oriented features, but it is complex and difficult to learn. The choice of which language to use depends on the type of computer used, type of program, and the expertise of the programmer.

Following are the most important features that would make a programming language efficient andeasy to use:

Clarity, Simplicity and Unity: A programming Language provides, both a conceptual frame work for thinking about algorithms and a means for expressing these algorithms. The syntax of a language should be such that programs may be written, tested and maintained with ease.

Orthogonality: This refers to the attribute of being able to combine various features of a language in all possible combinations, with every combination being meaningful. Orthogonality makes a language easy to learn and write programs, because there are fewer exceptions & special cases to remember.

Naturalness for the application: A language needs syntax that when properly used allows the program structure to reflect the underlying logical structure of the algorithm. The language should provide appropriate data structures, operations, control structures and natural syntax for the problem to be solved.

Support for abstraction: Even with the most natural programming language for an application, there is always a substantial gap remaining between the abstract data structures & operations that characterize the solution to a problem and the particular data structures and operations built into a language.

Portability of Programs: Portability is an important criterion for many programming projects which essentially indicates the transportability of the resulting programs from the computer on which they are developed to other computer systems. A language whose definition is independent of the features of a particular machine forms a useful base for the production of transportable programs.

Cost of use: Cost of use is measured on different languages like:
Cost of program execution: Optimizing compilers, efficient register allocation, design of efficient run-time support mechanisms are all factors that contribute towards cost of program execution. This is highly critical for large programs that will be executed continuously.
Cost of Program creation, testing & use: This implies design, coding, testing, usage& maintenance solutions for a problem with minimum investment of programmer time &energy.

Cost of Program Maintenance: The highest cost involved in any program is the total life-cycle costs including development costs & the cost of maintenance of the program while it is in production use.

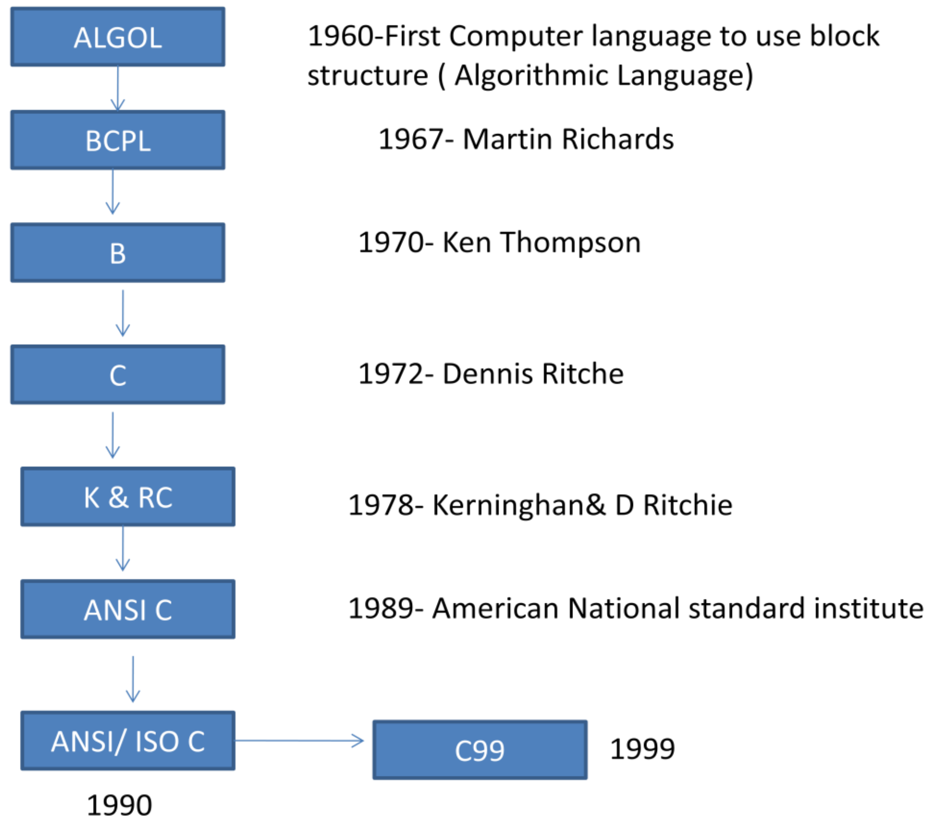
Evolution & Characteristics of C Language

During second generation of Computers (1956-57), commercial application problems used computers and this further increased in mid 60s.

- This lead to the development of a series of High-Level programming languages like BASIC, FORTRAN, COBOL, ALGOL, PASCAL, SNOBAL, PROLOG, LISP, etc., which were effectively used in problem solving.
- These High-Level programming languages were application specific

  Ex. FORTRAN was widely used for scientific processing
  COBOL was used for business data processing
  PASCAL was used for general application
  PROLOG & LISP for artificial intelligence applications
- Nowadays high level languages like C, C++, C# are becoming increasingly popular and earlier programming languages like BASIC, FORTRAN, COBOL, PASCAL, etc. are becoming outdated.
- This is because C language being a high level language satisfies varying requirements of users - like

  It can be used as systems programming language.
  The UNIX OS has been written in C.



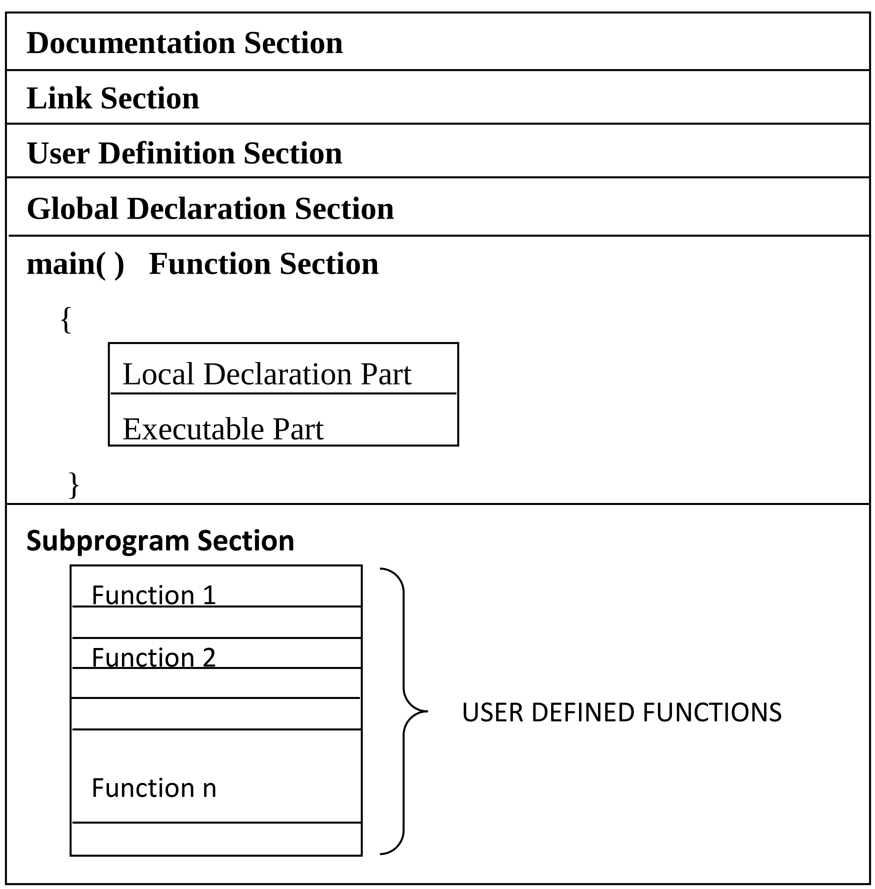
- Algol appeared only few years after FORTRAN, but was much more sophisticated.
- CPL was also big, but had very large number of features which made it difficult to learn and implement it.
- BCPL was modified CPL including only basic features.
- B was written by Ken Thompson for an early implementation of UNIX, which was a further simplification of CPL.
  (Both BCPL and B were useful only while dealing with certain kind of problems)
- Ritchie's achievement in C was to restore some of the lost generality in BCPL & B, mainly by the cunning USE OF DATA TYPES.
- In 1978, Dennis Ritchie and Brian Kernighan jointly published a detailed description of C language document, known as K & R 'C'. It was extensively used in Bell labs before it was released to commercial applications in 1978.
- Some of the drawbacks of K & R 'C' implementations are overcome by ANSI (American National Standards Institute) standards.

Characteristics of 'C'

- 'C' is a **general purpose programming language**.
  (1) It can be used for systems programming, and
  (2) It can be used to develop application programs required to solve a variety of scientific and engineering problems.

- ‘C’ language offers a close interaction with the interior (hardware) of the computer. It can be used to configure or change the hardware set-ups, memory locations/register contents, etc. Hence ‘C’ may be called a **Middle Level language** as it can be used both as a High Level language and a Low Level language.
- ‘C’ is a **structured programming language**. Program can be structured in form of functional modules or blocks. A proper collection of these modules makes a complete program. Such modular structure makes program debugging, testing and maintenance easier.
- ‘C’ is **highly portable**. That is, programs written on one computer can be run on any other computer with little or no modifications.
- ‘C’ has a **rich set of built-in-functions and operators** which can be used to write any complex program.
- ‘C’ supports **various data types** like integer numbers, floating point numbers, characters, etc.
- ‘C’ has a very **few keywords** (reserved words – only 32).
- ‘C’ is **case sensitive**, for example **num** is different from **NUM**.
- ‘C’ **supports pointers** and operations on pointers.

BASIC STRUCTURE OF A ‘C’ PROGRAM



Documentation Section:

- Consists of a set of comment lines giving the name of the program, author, and other details which the programmer would like to use later.
- These are non executable lines i.e., compiler ignores these comment lines.

Example:

/* Computing and Printing Employee's Salary Slip */
/* Prepared by 'H' Section students, NMAMIT, NITTE */
/*   Prepared on March, 2006   */

Link Section:

It provides instruction to the compiler to link functions from the system library.

Example :   #include <stdio.h>
             #include <math.h>
             #include <string.h>

User Definition Section:

In this section the user defines all SYMBOLIC CONSTANTS

Example :   #define PI 3.141
             #define CITY "Bangalore"
             #define CONDITION 'y'
             #define AVEARGE 76.35

Note: Link Section and User Definition Section are together called as the 'PREPROCESSOR STATEMENTS' OR 'PREPROCESSOR DIRECTIVES'

Global Declaration Section:

- Some variables or functions in the program are required to be accessed by more than one function. They have to be declared as global variables or global functions.
- Such Global declaration have to be made before the main( ) function.

main( ) Function:

- Every 'C' program must have only one main( ) function.
- Execution of 'C' program starts from the main( ) function.
- It should be written in lower case letters and should not be terminated by a semicolon.
- It calls other library functions and user defined functions

Braces:

- A pair of curly braces '{' & '}' are used in the main( ) function section.
- The left brace {represents the beginning of execution of the main function and the right brace} represents the end of execution of the main function.

- These braces are also used to indicate the begining and end of user-defined functions and compound statements.

Local Declaration Part:

- This part of the main( ) function declares all the variables used in the executable part
- Some of the variables may be initialized, i.e., assigned with initial values.

Examples:

```
int a,b=11,c;
float m=23.05,n;
char c1='y',c2=' ',c3='n';
void Show(int x,int y);
```

Executable Part:

- This part consists of statements which are instructions to computer to perform specific operations.
- They may be input-output statements, arithmetic statements, control statements and other statements.
- All such statements terminate with a semi colon.

Sub Program Section:

- This section consists of user defined functions.
- User defined functions are functions written by user to perform a specific task.
- They are declared in the Global or Local declaration section.
- They may be written after or before the main( ) function.

```
/***********DOCUMENTATION SECTION*************/
/* PROGRAM TO COMPUTE AREA OF A CIRCLE
   PREPARED BY XYZ
   PREPARED ON 26-02-2006 */

/*************LINK SECTION*******************/
#include <stdio.h>
#include <conio.h>

/***********USER DEFINITION SECTION**********/
#define PI 3.141

/**********GLOBAL DEFINITION SECTION**********/
void Accept();
void Compute();
void Show();
```

```
float rad,area;

/**********MAIN() FUNCTION SECTION***********/
void main()
 {        /* Start of main() function        */
  clrscr();  /* To clear the dispaly screen      */
  Accept();  /* To read in the input data values */
  Compute(); /* To compute the result            */
  Show();    /* To display the result            */
 }        /* End of main() function          */

/***********SUB PROGRAM SECTION***************/

void Accept() /*User defined function 1 */
 {
  printf("\n\n\tEnter the radius of the circle:");
  scanf("%f",&rad);
  return; /*Return to main function */
 }

void Compute() /*User defined function 2 */
 {
  area=PI*rad*rad;
  return; /*Return to main function */}

void Show()  /*User defined function 3 */
 {
  printf("\n\n\tThe Area of circle is: %f",area);
  getch();
  return; /*Return to main function */
 }
```

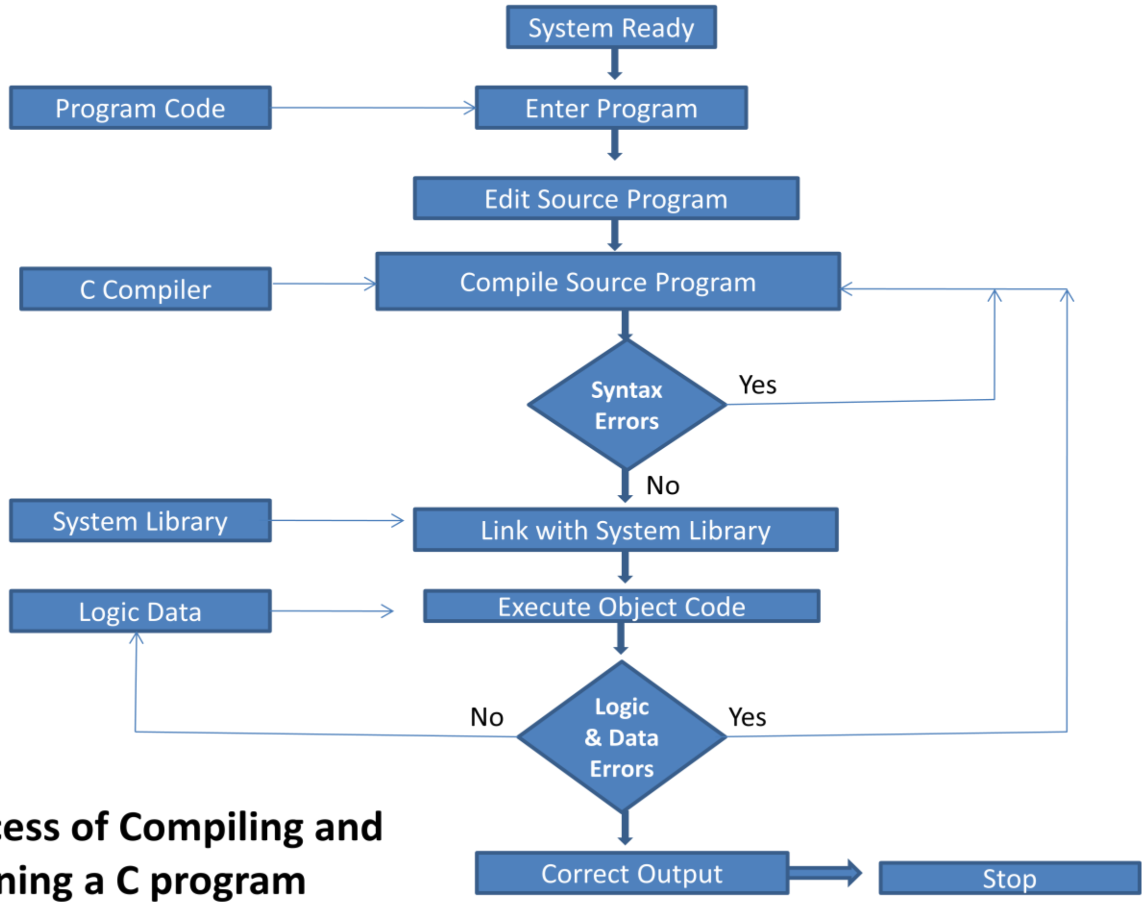
Compiling and Executing a ‘C’ Program:

- Compiling a ‘C’ program means translating it into a computer understandable form known as machine language. Compilation is done by a ‘C’ compiler.
- A compiler is a program which accepts the source code (actual ‘C’ program) as input and translates it to machine understandable form.
- ‘C’ compilers are available with or without editors. An editor is a program which allows the programmer to type in (key in) the program and modify (edit) it.
- Integrated Development Environment (IDE): It is an environment (a package) where we find the compiler, editor, debugging tools, linking facilities, tracing and testing tools. Example: Code Blocks, Turbo C (TC), Borland C, Microsoft C/C++, ANSI C, etc.
- The procedures used in compiling and executing a ‘C’ program differ from one operating system to other.

Executing a C program written in C involves a series of steps, These are

- Creating the Program
- Compiling the Program
- Linking the program with the functions that are needed from the C library, and
- Executing the program.

Figure below illustrates the process of creating, compiling, and executing of C program, although these steps remains the same irrespective of the operating systems(OS) commands for implementing the steps and conventions for naming ***files*** may differ on different systems.
An OS is a program that controls the entire operation of computer system. All input/output operations are channeled through the OS. The OS which is an interface between the hardware and the user, handles the execution of user program.



Process of Compiling and Running a C program

‘C’ Character Set

<table>
<tr><td>Alphabets</td><td colspan="2">Upper Case A to Z
Lower Case a to z</td></tr>
<tr><td>Digits</td><td colspan="2">0 through 9</td></tr>
<tr><td>Special Characters</td><td>, Comma
. Period
: Colon
; Semicolon
‘ Apostrophe (single quote)
“ Double quote
? Question mark
! Exclamatory mark
_ Under score
Hash
= Equal sign
| Pipeline character
+ Plus sign
– Minus sign
* Asterisk</td><td>/ Slash
% Percentage
& Ampersand
^ Caret
~ Tilde
< Less than
> Greater than
\ Back slash
(Left parenthesis
) Right Parenthesis
[Left bracket
] Right bracket
{ Left brace
} Right brace</td></tr>
</table>

‘C’ Tokens

They are the smallest units or primitive elements of the grammar or syntax of ‘C’ language. Each and every line of a ‘C’ program will contain one or more ‘C’ tokens.

There are six types of tokens in ‘C’:

(1) Keywords (Reserved words)
(2) Identifiers (Variable names)
(3) Constants (Literals)
(4) Strings
(5) Operators
(6) Other special symbols

Example1: Consider the declaration statement in ‘C’

int n1, n2, sum ;

Here ‘C’ tokens are:

Here ‘C’ tokens are:	int	is a keyword
	n1 n2 sum	are identifiers/variables
	, , ;	are special symbols used as delimiters

Example2: Consider an assignment statement in 'C'

bal = amount – debit ;

Here 'C' tokens are:

=, - , are operators

bal ,amount ,debit -> are identifiers/variables

; is a special symbol used as delimiters

Keywords used in 'C':

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

Identifiers:

- They are names of variables representing data, labels, function names, array names, user-defined names, user-defined objects, etc.
- They are formed by sequences of alphabets and digits

Rules for forming identifier names:

(1) The first character must be an alphabet (uppercase or lowercase) or an underscore "_"
(2) All succeeding characters must be either letters or digits
(3) Uppercase and lowercase identifiers are different in 'C' i.e., identifiers are case sensitive
(4) No special characters or punctuation symbols are allowed except the underscore "_"
(5) No two successive underscores are allowed
(6) Keywords should not be used as identifiers

Examples of VALID identifiers in C

ping	sumup2	at_a_rate	story_of_1942
tick20	_check	balance	Q123
qlty_02	iNUM	Cost	one2next

Examples of INVALID identifiers in C

1stnum	+point	rate_in_$	flash@
min bal	Rs..	break	continue
tot__pay			

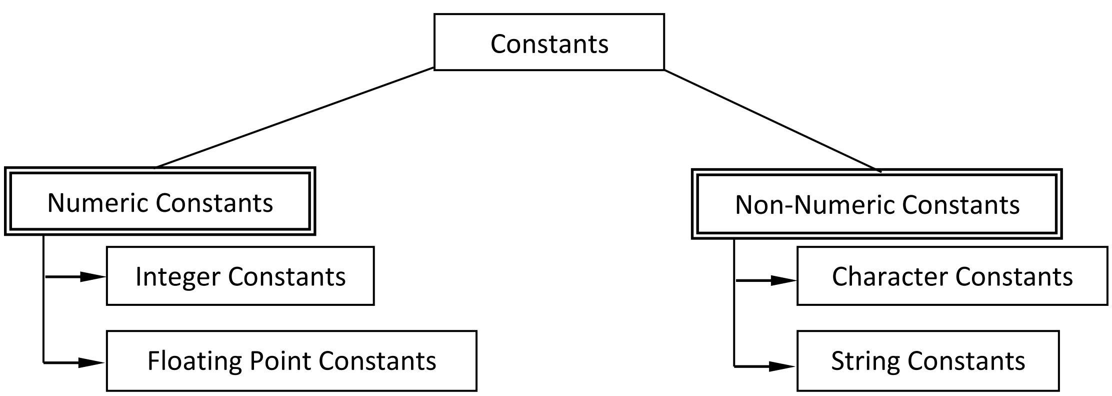
- Names of the identifiers once declared in C cannot be used to declare some other function name or array name in a single program.
- Number of significant characters to be recognized in an identifier varies from C compiler to C compiler

Constants and **Variables** are two essential ingredients for **Data Processing Applications** without which we may not be able to develop programs in any of the high level programming languages.

Constants:

These are fixed values that do not change during the execution of a program. They are also known as **literals**.

In 'C' constants can be classified as:



Numeric Constants:

- They are simply numbers, a collection of one or more decimal digits.
- They are used for performing numeric calculations.

Non-Numeric Constant:

- These comprise of both numerals and letters of alphabets including special symbols.
- They are used in string manipulation applications like *Natural Language Processing (NPL)*

Integer Constants:

- Integer constants in ‘C’ represent whole numbers without any fractional part.
- It is a sequence of digits without a decimal point.
- It can be prefixed with a plus or minus sign.
- When minus sign doesn’t precede the number, it is assumed to be a positive one.
- There should not be any special symbols like blank spaces, comma, etc.

The general form of an integer constant is:

Sign	Digits

where,

Sign→ optional plus sign for positive numbers and minus sign for negative numbers.

Digits→ a sequence of digits

INTEGER CONSTANTS	
VALID	**INVALID**
2006 123 –902 +27 999 0 –6 +2	0.0 –15ºC 1,25,200 10 456 0.027 345+ 100.

THREE TYPES OF INTEGER CONSTANTS IN ‘C’	
DECIMAL INTEGER CONSTANTS	• Any combination of digits from 0 to 9 • Preceded by optional + or – sign • Valid examples: 123, 109, –78, 0, 76594, +236
OCTAL INTEGER CONSTANTS	• Any sequence of one or more digits from 0 to 7 • An octal constant must start with 0 • It can be a positive or negative octal number with signs ‘+’ or ‘–’ • Valid examples: 027, –0126, +052, 0551
HEXA DECIMAL INTEGER CONSTANTS	• Any sequence of one or more digits from 0 to 9 inclusive of alphabets from ‘A’ to ‘F’ or ‘a’ to ‘f’. • An octal constant must start with 0x or 0X • It can be a positive or negative hex number with signs ‘+’ or ‘–’ • Valid examples: 0X2, 0x9F, 0Xbcd, –0x23E

Floating Point Constants:

Floating point constants are real numbers with a decimal point embedded in it.

A floating point constant can be written in two forms:

1. Decimal or Fractional form:
   - It should contain atleast one digit to the right of the decimal point.
   - A '+' sign or a '–' sign may precede it. If the sign doesn't precede then the number is assumed to be positive.
   - The general form of the Decimal form of floating point constant is:

Sign	Integer part	Decimal point	Fractional part

where,

Sign → optional plus or minus sign

Integer part → a sequence of digits before the decimal point

Decimal point → period symbol

Fractional part → a sequence of digits after the decimal point

   - Examples: 1.5 –0.563 123.0 27009.023 –999.99

2. Exponential or Scientific form:
   - The floating point constant in the exponential form can be expressed as:

Mantissa	e	Exponent

where,

Mantissa → is either a **real number** expressed in decimal form or an **integer**

e → alphabet 'e' (lower case) or 'E' (upper case)

Exponent → it is an integer number with an optional '+' or '–' sign

   - Examples: 0.4876E12 –235.46e–102 +0.001E–97
     –43.2e06 156E+05 –1.234e–07

   - Exponential notation is useful for representing numbers that are either very large or very small in magnitude. Example: 3500000000 may be written as 3.5E9 &–0.000000456 can be written as –4.56E–7

Character Constants:

- A character constant in ‘C’ is a single character enclosed within a pair of single quotes.
- Examples: ‘u’, ‘s’, ‘$’, ‘6’, ‘ ’, ‘?’, ‘!’, etc.
- Each character constant in ‘C’ is identified with its ASCII integer value.
- Character constants in ‘C’ are used mainly to represent some coding during data output.

String Constants:

- A string constant in ‘C’ denotes a sequence of one or more characters enclosed within a pair of double quotes.
- Examples: “Hi” “y2k problem”“15th August” “2006”
  “Welcome to C” “20% Loss”

- A single character string doesn’t have an equivalent integer value, but a single character constant has an integer value. Eg. “A” and ‘A’ are not the same.

Backlash Character Constants:

- ‘C’ supports some special backlash character constants that are used in output function printf to obtain special print effects.
- It is a combination of two characters in which the first character is always a backlash ‘\’. The second character can be any one of the characters a, b, f, n, t, v, ’, ”, \ and 0.
- They are also known as ‘Escape Characters’ or ‘Escape Sequences’.
- A list of the Backlash Constants used are listed in table below:

Backlash Constants	**Meaning**
\a	System Alarm (Bell or Beep)
\b	Backspace
\f	Form feed
\n	New line (Line feed)
\r	Carriage return (CR)
\t	Horizontal tab (Fixed amount of space)
\v	Vertical tab
\”	Double quote
\’	Single quote
\?	Question mark
\0	Null character
\\	Backlash character itself

Variables:

A variable may be a data name that may be used to store data value.

- They are used to identify different program elements, hence also known as ‘Identifiers’.
- A variable may take different values at different times during execution of the program.
- Each variable refers to specific memory locations in the Memory Unit where numerical values or characters can be stored.
- Example: sum = n1 + n2 here, n1 & n2 are variable names representing two different quantities in two distinct memory locations. Similarly, sum is also a variable name which holds the sum of n1 and n2.
- Other examples: area, amount, class_strength, condition, etc.

Rules for forming variable or identifier names:

1. The first character must be an alphabet (uppercase or lowercase) or an underscore “_”
2. All succeeding characters must be either letters or digits.
3. An ANSI standard recognizes a length of 31 characters. Many compilers treat only first 8 characters in the variable name as significant. (Presently, there is no limit on the variable name length).
4. Uppercase and lowercase identifiers are different in ‘C’ i.e., identifiers are case sensitive, so Sum SUM and sum each are different variable names.
5. No special characters or punctuation symbols are allowed except the underscore “_”
6. No two successive underscores are allowed, white spaces not allowed.
7. Keywords should not be used as identifiers.
8. Writing the variable names in lower case letters is a good practice.
9. Choose meaningful names to variables which reflect the functionality or nature of the variable.

Valid Variables	**Invalid Variables**
part_no , author x2 , ph_value total_marks_2006	2006salary , %sum (actual_bill) , ph value total__marks , long

The Four fundamental data types:

'C' supports four basic data types:

Data type	Keyword	Size (in bytes)
Integer	int	2
Real (Floating point)	float	4
Double precision real	double	8
Character	char	1

int data type:

- int is the key word used to denote integer number.
- Integer constants in 'C' represent whole numbers without any fractional part.
- Integer numbers are stored on 16 bits (2 bytes).
- It is a sequence of digits without a decimal point.
- It can be prefixed with a plus or minus sign.
- When minus sign doesn't precede the number, it is assumed to be a positive one.
- There should not be any special symbols like blank spaces, comma, etc.
- The range of integer number that can be stored depends on the word length of the computer. (word length: No. of bits accessed by processor at a time)
- For a 8 bit computer, range of int is given as:

  $-2^{8-1} \leq$ integer number $\leq +2^{8-1}-1$

  $-128 \leq$ integer number $\leq +127$

- For a 16 bit computer, range of int is given as:

  $-2^{16-1} \leq$ integer number $\leq +2^{16-1}-1$

  $-32786 \leq$ integer number $\leq +32767$

- Examples of valid int data type: 2006 123 –902 +27 999 0 –6 +2
- Examples of invalid int data type: 0.0 –15°C 1,25,200 10 456 0.027 345+ 100.

float data type:

- float is the key word used to denote a real number or floating point number (both in fractional form and exponential form).
- Floating point numbers are stored in 32 bits (4 bytes) with 6 digits of precision.

- Examples: 1.5 –0.563 123.0 27009.023 –999.99
  0.4876E12 –235.46e–102 +0.001E–97
  –43.2e06 156E+05 –1.234e–07

double data type:

- double is the key word used to denote a double precision floating point number.
- This is similar to float data type, only difference is that it is used to represent more precision of the floating point number.
- Double precision floating point numbers are stored in 64 bits (8 bytes) with 16 digits of precision.

char data type:

- char is the keyword used to denote a character data type.
- A character constant in 'C' is a single character enclosed within a pair of single quotes.
- A character data type is stored on 8 bits (1 byte)
- Examples: 'u', 's', '$', '6', ' ', '?', '!', etc.
- Each character constant in 'C' is identified with its ASCII integer value.

Character	**ASCII**	**Character**	**ASCII**	**Character**	**ASCII**	**Character**	**ASCII**
'A'	65	'a'	97	'0'	48	'='	61
'Z'	90	'z'	122	'&'	38	'{'	123

Data type modifiers:

The storage size in bytes and range of values being represented by basic data types can be modified with the help of the following **modifiers** or **qualifiers** as prefixes.

1. signed
2. unsigned
3. long
4. short

signed

- This modifier can be applied to integer variables although default integer declaration already assumes a signed number.
- In a signed data type, the first bit (known as the most significant bit) is used to store the sign. If this bit is 0, the number is positive. If it is 1, the number is negative.
- A signed int data type can hold values in the range –32786 to 32767
- When signed modifier is prefixed to char data type, it can store small integers in the range –128 to +127.

unsigned

- This modifier can be applied to both int and char data type variables.
- However, char data type is unsigned by default and can hold integer values in the range 0 to 255.
- An unsigned int data type can hold integer values in the range 0 to 65535

long

- This modifier can be applied to both int and double data types.
- When applied to int, it doubles the storage size from 2 bytes to 4 bytes.
- long int can store integer values in the range –2147483648 to +2147483647
- A long integer can also be declared as long int or simply long.
- When applied to double data type, the storage size increases from 8 bytes to 16 bytes.
- Long double can store floating point number values in the range –3.4E–4932 to +1.1E+4932

short

- This modifier can be applied to integer data type.
- It changes the size of int to its half. But since most of the compilers have 16 bits int, and the same size is maintained for short int also.

Modifier	**Size (Bytes)**	**Range of values**
int	2	–32768 to +32767
signed int	2	–32768 to +32767
unsigned int	2	0 to 65535
short int	2	–32768 to +32767
long int	4	–2147483648 to +2147483647
unsigned short int	2	0 to 65535
unsigned long int	4	0 to 4294967295
char	1	–128 to +127
signed char	1	–128 to +127
unsigned char	1	0 to 255
float	4	–3.4E+48 to +3.4E+48
double	8	–1.7E+308 to +1.7E+308
long double	16	–3.4E–4932 to +1.1E+4932

Declaration of variables:

- All the variables must be declared before they are used in a ‘C’ program
- Declarations are necessary to indicate to the compiler the type of variable and to reserve the amount of memory required to store the values held by them.
- The syntax for declaring a variable is as follows:

data type	variable list	semicolon

where,

data type → Basic data type such as int, float, char, double, etc

variable list → one or more variables of the above data type.

Semicolon → a delimiter of this declaration.

- Examples: **int** count, i, j;

float average, sum, K[100];

char ch, ans;

double populn, cluster;

char city[30], train[20];

Assigning values to variables:

- The process of giving values to variables is known as “Assignment of values” to variables.
- The assignment operator ‘=’ is used to assign a value to a variable.
- The value assigned to the variable is stored in the memory location that was reserved for it during declaration.

Its syntax is:

Variable_name	=	value	;

Where,

Variable_name → represents the name of the variable where it must be stored.

= → is the assignment operator

value → is a constant or a variable

Two methods of assigning values to variables:

1. Assigning initial values to variables within the declaration section. This is called **initialization**.

   Example: int i, gd = 10, gm;

   float n1, n2, sum = 0.0;char status, condn = ‘y’;

   char place[ ] = “NITTE”, college[50];

2. Assigning values to variables in the executable part of the program.

   Example: int k, num =30;

   float m;

   char ch;

   char name[50];

   Declaration

   k = num;

   m = 3.45;

   name = “MsBeautiful”;

   ch = ‘N’;

   Assignment

Assignment Statements:

- An assignment statement has the following format (or syntax)

Variable_name	=	Expression	;

Where,

Variable_name → represents the name of the variable where it must be stored.

= → is the assignment operator

Expression → is

- constant or a variable
- function name or function call
- array reference or structure reference
- variables and/or constants coupled with operators

Examples of valid assignment statements:

bonous_pay = (basic_pay * 12)/100;

test_avg = (t1m + t2m + t3m)/3 ;

d = b * b – 4 * a * c;   y = num[8];

int_rate = 5.25;   big = largest(a,b,c);

Examples of invalid assignment statements:

x-y = x + y;

basic_pay + hra = gross_pay;

balance + 120 = int_rate * principal;

(a * a – b)/2.6 = d * d – c * c;

125 = reg_no;

Note: Expression must always come to the right side of the assignment operator '='

Short hand assignment operators:

'C' has special short hand operators which will simplifies representation of certain assignment statements.

Examples:

sum_of_digits_of_numbers=sum_of_digits_of_numbers+digit;

decrement_of_loop = decrement_of_loop – 1;

The above assignment statements can be written using **short hand operators** as:

sum_of_digits_of_numbers += digit;

decrement_of_loop –= 1;

Here the special operators '+=' and '-=' are short hand operators.

The general syntax for using short hand operators in assignment statements is:

Variable_name	operator =	expression	;

Short hand operator	**Meaning**

+=	Add and assign
–=	Subtract and assign
*=	Multiply and assign
/=	Divide and assign
%=	Find remainder and assign

Valid examples of short hand operators:

Expression with short hand operator	**Meaning**
sum += heights;	sum = sum + heights;
p += a-b;	p = p + (a-b);
down_count –= 1;	down_count = down_count – 1;
q -= 1+r;	q = q – (1+r);
x_to_pn *= a;	x_to_pn = x_to_pn * a;
A *= 2/(B*B);	A = A * 2/(B*B);
income /= tax;	income = income / tax;
xyz /= sd-mn*a;	xyz = xyz / (sd-mn*a);
profit %= (inv*4-loan);	profit= profit%(inv*4-loan);

Benefits of using short hand operators:

- Assignment expressions are concise and easy to use
- Considerable saving over length of source code
- The variable name used on LHS of '=' operator need not be re-typed in the RHS.

Multiple assignment statements:

'C' allows us to assign a single value to more than one variable name at a time.

Example: x = y = z = 0.0;

z is assigned a value 0.0, now value of z is assigned to y; and then value of y is assigned to x.

- In multiple assignment statements, the assignment is 'Right associative' as evaluation or assignment will take place from **right to left**.

Example 1: a = b = (x+y=z)/2;

1. evaluation of (x+y+z)/2 will take place first
2. then the result is assigned to variable name b
3. finally, value of b will be assigned to a

Example 2: l = m= n *= p;

l = (m= (n *= p)); ←(right to left)

1. n = n*p
2. m = n
3. l = m

Note: Multiple assignments cannot be done during declaration of variable names.

Therefore, int p = int q = int r = 0;

int x = y = z = 144;

$\Bigg\}$ ARE **INVALID** IN 'C'

(In the above statements first the variables must be declared and then multiple assignment statements may be used)

Symbolic Constants:

- 'C' allows defining a variable name as having a constant value using a pre processor directive #define
- Such pre processor statements are placed at the beginning of the program and are not a part of the C program.
- Such statements begin with the **# symbol** and hence do not end with a semicolon.
- A symbolic constant can be used to define a numeric constant or a character/string constant.
- Once defined, a symbolic constant's value can be used at many places in the program.

The syntax of symbolic constant is:

#define	symbolic_name	value of constant

Examples:

#definePI	3.141
#defineCLASS	"H Section"
#defineMINI_BAL	500.0
#defineFLAG	'Y'

Note:

- A symbolic constant should not be used as any other variable name
- Once a symbolic constant is defined, its value cannot be changed in the program. Example: MINI_BAL = 1000.0; is illegal.
- There should not be white space between # and define

Declaring variables as Constant and as Volatile:

const type modifier:

- It is sometimes required that the value of a variable should denote a single value throughout the program execution.
- A qualifier or modifier 'const' is use to do so. This modifier 'const' must be placed before a data type declaration.

Examples:

```
const int max_count = 25;

const float int_rate = 6.25;

const char C = 'Y';
```

The above values of variables once initialized by the compiler cannot be changed.

volatile type modifier:

- It is sometimes required to dynamically change the value of a variable during program execution.
- The modifier or qualifier **volatile** is used for this purpose.

Examples:

```
volatile int score;

volatile float rate;
```

Delimiters:

- These indicate the boundary between the elements of a program
- They are also known as separators
- They separate constants, variables and statements.
- Comma, semicolon, single quotes, double quotes, blank spaces, etc. are the most commonly used delimiters.

Chapter 3: Operators and Expressions

- C supports a rich set of operators. Operators are used in programs to **manipulate data variables.**
- An operator is a **symbol** that tells the computer to perform certain mathematical or logical manipulation.
- Operators usually form a part of the **expressions** and indicate the type of expressions – **mathematical** or **logical expressions.**
- The values that can be operated by these operators are called **operands**.

The different types of operators in 'C' are:

C OPERATORS			
Unary Operators	**Binary Operators**	**Ternary Operator**	**Special Operators**
• Unary Minus • Logical NOT • Bitwise Complementation	• Arithmetic Operators • Logical Operators • Relational Operators • Bitwise Operators	• A type of conditional operator in C	• Comma Operator • **sizeof()** operator • Address operator • Dereferencing operator • Dot operator • Arrow operator

(A) Unary Operator:

An operator that acts on only one kind of operand is known as unary operator.

Types of unary operators are:

(1) Unary Minus (2) Logical NOT operator (3) Bitwise complementation

(1) Unary Minus:

Any positive operand with unary minus operator changes its value to negative.

In effect, it multiplies its single operand by -1.

Example:

Let x = 10, y = 5

z = x + (-y)

= 10 + (-5) = 5

The logical NOT operator is considered later in Logical operators and bitwise complementation is considered in bitwise operators.

(B) Binary Operators:

These operators act on two operands and hence are named as binary operators.

We have four types of binary operators,

(1) Arithmetic Operators (3) Logical Operators

(2) Relational Operators (4) Bitwise Operators

(1) Arithmetic Operators:

- The basic arithmetic operations addition, subtraction, multiplication and division can be performed on any built-in data type of C using these operators.
- Another operator, the modulus operator is added to the list of Arithmetic operators. It is used to find the remainder after integer division.

Operator	Meaning
+	Addition
–	Subtraction or Unary Minus
*	Multiplication
/	Division
%	Modulus or Modulo Division

Note:

(1) The modulus operator % can be used only for integer operands and not for floating point operands.

(2) C does not have a operator for exponentiation. This can be performed by a library function **pow()**.

Examples of arithmetic operators are:

a – b	a + b	where 'a' and 'b' are operands
a * b	a / b	
a % b	-a * b	

(a) Integer Arithmetic:

- When both the operands in a single arithmetic expression are integers, the expression is called **integer expression** and the and the operation is called **integer arithmetic**.
- Integer arithmetic always yields an integer value.

Examples: if a = 17 and b = 4, the following are the results of integer arithmetic.

a – b = 13

a + b = 21

a * b = 68

a / b = 4 (decimal part truncated)

a % b = 1 (remainder of division)

```
/****Use of Modulus operator****/
#include <stdio.h>
#include <conio.h>

main()
 {
  int months,tot_days,days;
  clrscr();
  printf("\n\n\tEnter the no. of days:");
  scanf("%d",&tot_days);
  months=tot_days/30;
  days=tot_days%30;
  printf("\n\n\t%d days = %d months & %d days", tot_days,
                    months, days);
  getch();
 }
```

Output of Program:

```
Enter the no. of days: 200
```

(b) Floating point OR Real Arithmetic:

- An arithmetic expression involving only real (or floating point) operands is called Real Arithmetic.
- A real operand may assume values either in the decimal or exponential form.
- The result of real arithmetic operation is an approximation of the correct result to the number of significant digits permissible.
- The modulus operator % cannot be used with real operands.

Examples: if x = 8.3, y = 3.2 and z are floats, then we will have:

z = x + y = 11.500000

z = x / y = 2.593750

z = -y/x = -0.385542

(c) Mixed-mode Arithmetic:

- The arithmetic operation in which one of the operand is real and the other is integer, is called mixed-mode arithmetic operation.
- The value of such an expression is a float.
- But if the result is assigned to an int variable, the decimal portion of the result is truncated and only integer portion is assigned to the int variable.
- Example: int n;

  n = 5/3 + (3/2.0)

  n = 1 + (1.5) = 2.5

  But ‘n’ is an integer variable, so only the integer part o 2.5 i.e., 2 is assigned to ‘n’. Therefore, n = 2.

Arithmetic Expressions:

- An expression involving arithmetic operators is called an arithmetic expression.
- These expressions connect one or more operands (integer or real) through arithmetic operators.
- The conventional mathematical expressions that we normally write must be converted into equivalent C expressions as C compiler understands only the symbols provided in the C character set.

Some sample expressions and their C equivalent expressions are:

Mathematical Expression	C Equivalent
$\frac{a+b}{a-b}$	(a+b)/(a-b)
$\frac{2x^2}{p+q}\times(1-m^2)$	(2*x*x/(p+q))*(1-m*m) OR (2*x*x*(1-m*m))/(p+q)
$T=\frac{2m_1m_2}{m_1+m_2}\times g$	T = 2*m1*m2*g/(m1+m2) OR T = (2*m1*m2/(m1+m2))*g
$side=\sqrt{a^2+b^2-2ab\cos(x)}$	side=sqrt(a*a+b*b-2*a*b*cos(x))
$E=m\left[gh+\frac{v^2}{2}\right]$	E=m*(g*h+v*v/2)
$e^{\lvert a\rvert}+b$	exp(abs(a))+b
$x=e^{\left\lvert\frac{y}{\sqrt{1+\sin\theta}}\right\rvert}$	X=exp(abs(y/sqrt(1.0+sin(theta))))

Evaluation of Arithmetic expressions:

- Arithmetic expressions are evaluated from left to right
- Operands associated with highest priority are operated first

Arithmetic Operations	Priority
Multiplication, Division and Modulus	Highest priority
Addition and Subtraction	Lowest priority

Rules for evaluation of arithmetic expressions:

- If the given expression involves parentheses, then the expression inside the parentheses must be evaluated first.
- The parenthesized and unparenthesized expressions follow the operator precedence as given in table above.
- If a unary minus is present in the expression, then the term associated with unary minus must be evaluated before any other expressions.

Example:

2*((i/3)+4*(j-2))   given i=8 and j=5

=2*((8/3)+4*(5-2))

=2*(2+4*(5-2))

=2*(2+4*3)

=2*(2+12)

=2*14

=28

Increment and Decrement Operators:

- C has two very useful operators generally not found in other languages.
- They are: **Increment Operator** denoted by ++
  and **Decrement Operator** denoted by --
- The increment operator ++ adds 1 to the operand while -- subtracts 1 from the operand.
- These operators act only on integer operands.
- Both are **unary operators** taking the form

  ++m or **m++**   which is equivalent to **m = m + 1**

  --m or **m--**   which is equivalent to **m = m - 1**
- Increment and Decrement Operators are used extensively in **for** and **while** loops.
- ++m and m++ (or --m and m--) mean the same when they are used independently in statements which are not expressions.

- They behave differently when they are used in expressions on right-hand side of an assignment statement as shown in table below.

Expression	Meaning	Known as
x = ++a;	**a = a+1;** **x = a;**	**Pre increment** – Integer variable on RHS will be incremented first, then it's new value is assigned to variable on LHS.
x = a++;	**x = a;** **a = a+1;**	**Post increment** – Present value of integer variable on RHS is first assigned to variable on LHS, then integer on RHS is incremented.
y = --b;	**b = b-1;** **y = b;**	**Pre decrement**– Integer variable on RHS will be decremented first, then it's new value is assigned to variable on LHS.
y = b--;	**y = b;** **b = b-1;**	**Post decrement**– Present value of integer variable on RHS is first assigned to variable on LHS, then integer on RHS is decremented.

```
/***Use of increment and decrement operators***/
#include <stdio.h>
#include <conio.h>
main()
{
 int a=10,b=12;
 clrscr();
 printf("Given a = %d and b = %d",a,b);
 getch();
 printf("\na++ = %d",a++);
 getch();
 printf("\nb-- = %d",b--);
 getch();
 printf("\nNow a = %d",a);
 getch();
 printf("\nNow b = %d",b);
 getch();
 printf("\n++a = %d",++a);
 getch();
 printf("\n--b = %d",--b);
 getch();
}
```

Output of the program:

```
Given a = 10 and b = 12
a++ = 10
b-- = 12
```

(2) Relational Operator:

- These are used to compare two operands. For example, compare the ages of two persons, compare the prices of two or more items, etc.
- They result in either a TRUE (Non-zero) value or FALSE (Zero) value.

Operator	Meaning	Precedence	Associativity
<	Lesser than	1	L to R
<=	Less than or equal to	1	L to R
>	Greater than	1	L to R
>=	Greater than or equal to	1	L to R
==	Equal to	2	L to R
!=	Not equal to	2	L to R

Examples:

x > y

age == 25

cost <= 125.5

i != 10

days < 365

Relational Expressions:

- A simple relational expression contains only one relational operator. Its syntax is a follows:

ae1	relational_operator	ae2

where, ae1 and ae2 are arithmetic expressions, which may be simple constants, variables or combination of them.

- When arithmetic expressions are used on either side of a relational operator, the arithmetic expressions will be evaluated first and then the results compared. That is, arithmetic operators have a higher priority over relational operators.
- Relational expressions are used in ***decision statements*** such as **if** and **while** to decide the course of action of a running program.

- Suppose a and b are two float point variables holding values 4.5 and 10.0,

Expression	Interpretation	Value
a <= b	TRUE	1
a < -b	FALSE	0
a*9 > 0	FALSE	0
a + 5 < b * 2	TRUE	1
a*b == b*a	TRUE	1

```
/***Program to illustrate the use of relational operator***/
#include <stdio.h>
#include <conio.h>
main()
{
  int a, b;
  float n1, n2;
  clrscr();
  printf("\n\nEnter two integers and two real numbers:");
  scanf("%d %d %f %f",&a, &b, &n1, &n2);
  if(a == b)
    printf("\n\n a and b are equal");
  else
    printf("\n\n a and b are unequal");
  getch();
  if(n1 > n2)
    printf("\n\n n1 is greater than n2");
  else
    printf("\n\n n1 is not greater than n2");
  getch();
}
```

Output of Program:

1. Enter two integers and two real numbers: 10 20 2.5 0.25

    a and b are unequal

    n1 is not greater than n2

2. Enter two integers and two real numbers: 6 6 25 12.5

    a and b are equal

    n1 is greater than n2

(3) Logical Operators:

- Logical operators are used in C to take decisions.
- C has the following three logical operators:

Operator	Meaning	Precedence	Associativity
&&	Logical AND	2	L to R
||	Logical OR	3	L to R
!	Logical NOT	1	L to R

- && and || are binary operators and ! is a unary operator.
- The result of these operators is either TRUE (ONE) or FALSE (ZERO).
- The logical operators are used to connect one or more relational expressions.
- Such an expression which combines two or more relational expressions is called as **logical expression** or **compound relational expression**.
- While using logical AND
    - if both the operands are TRUE, then the result of the logical expression is TRUE.
    - even if one of the operands is FALSE, then the result of the logical expression is FALSE.
- While using logical OR
    - Only if both the operands are FALSE, then the result of the logical expression is FALSE.
    - Even if one of the operands is TRUE, then the result of the logical expression is TRUE.
- While using logical NOT, the compliment of the operand is obtained. That is, if the operand is TRUE, than the result will be FALSE or vice-versa.
- The results of the operands are shown in Truth table shown below:

Op1	**Op2**	**Value of Expression**			
		Op1 && Op2	**Op1 || Op2**	**!Op1**	**!Op2**
T	T	T	T	F	F
T	F	F	T	F	T
F	T	F	T	T	F
F	F	F	F	T	T

Examples of Logical Expressions:

1. **if(age > 55 && salary < 50000)**
2. **if(number < 0 || number > 100)**

Suppose a, b and c are integers having values, 2, 4 and 3,

a && b || c && (!b)

= 2 && 4 || 3 && (!4)

= 2 && 4 || 3 && 0

= 1|| 3 && 0

= 1||0

= 1

```
/***PROGRAM TO ILLUSTRATE USE OF LOGICAL OPERATORS***/
#include <stdio.h>
#include <conio.h>
main()
{
 int a,b,c;
 clrscr();
 a = 10; b = 5;
 c = a && b;
 b = a || b || c;
 a = a && b || c;
 printf("\n\n%d %d %d",a,b,c);
 getch();
}
```

Output of the program:

```
1 1 1
```

(4) Bitwise Operators in 'C':

- All the data stored in the computer memory are in sequences of bits (0s and 1s).
- Some applications require the manipulation of these bits.
- Manipulation of individual bits is carried out in machine language or assembly language.
- 'C' provides **six operators** to perform **bitwise operations**.
- These operators work only with **int** and **char** data-types. They cannot be used with floating point numbers.

The six bitwise operators in 'C' are:

Operator	Meaning
&	Bitwise AND
|	Bitwise OR
^	Exclusive OR (XOR)
~	1's complement
<<	Left shifting of bits
>>	Right shifting of bits

(a) Bitwise AND:

Result of bitwise AND is 1 when both the bits are 1, otherwise it is zero.

b1	b2	b1 & b2
0	0	0
0	1	0
1	0	0
1	1	1

Examples:

1. Considering normal binary digits.

int a = 4, b = 3;

Equivalent binary value of a = 4 is 0000 0100

Equivalent binary value of b = 3 is 0000 0011

a & b is 0000 0000

Decimal	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

2. Considering BCD (Binary Coded Decimal).

int m = 120, n = 060, p;

Equivalent BCD of m = 120 is 001 010 000

Equivalent BCD of n = 060 is 000 110 000

p = m & n is 000 010 000

(b) Bitwise OR (|):

Result of bitwise OR is 1 when one of the bits is 1, otherwise (when both bits are 0s) it is zero.

b1	**b2**	**b1 | b2**
0	0	0
0	1	1
1	0	1
1	1	1

Examples:

1. Considering normal binary digits.

int a = 6, b = 4;

Equivalent binary value of a = 6 is 0000 0110

Equivalent binary value of b = 4 is 0000 0100

a | b is 0000 0110

2. Considering BCD (Binary Coded Decimal).

int m = 340, n = 723, p;

Equivalent BCD of m = 340 is 011 100 000

Equivalent BCD of n = 723 is 111 010 011

p = m | n is 111 110 011

(c) Exclusive OR (XOR ^) :

Result of bitwise XOR is 1 if the bits are different (1 and 0 or 0 and 1), otherwise (when both bits are 0s or both bits are 1s) it is zero.

b1	b2	b1 ^ b2
0	0	0
0	1	1
1	0	1
1	1	0

Examples

Considering normal binary digits.

int a = 6, b = 4;

Equivalent binary value of a = 6 is 0000 0110

Equivalent binary value of b = 4 is 0000 0100

a ^ b is 0000 0010

(d) One's Complement (~):

- The bitwise complement operator is an unary operator which reverses the state of each bit within an integer or character.
- Each 'zero' get changed to 'one' and each 'one' gets changed to 'zero'.

Example:

int b = 12;

= 1100 (in binary form)

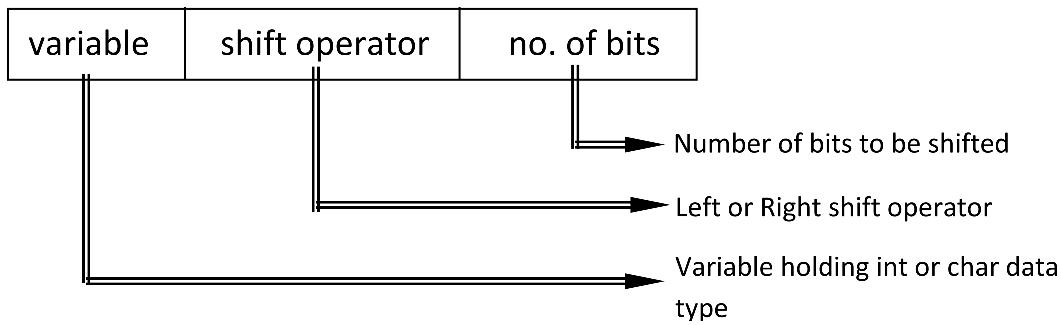
∴ a = ~b

= 0011

(e) Left Shift Operator (<<) and Right Shift Operator (>>):

The left shift operator << shifts the bits to the left and the right shift operator >> shifts the bits to the right.

General syntax for bitwise shift operator:



Examples: m >> 2

n << 1

Example for bitwise left shifting:

Consider an integer variable a = 208

In binary form it is a =	1	1	0	1	0	0	0	0
a << 1 =	1	0	1	0	0	0	0	0

Example for bitwise right shifting:

Consider an integer variable a = 208

In binary form it is a =	1	1	0	1	0	0	0	0
a >> 2 =	0	0	1	1	0	1	0	0

```
/***PROGRAM TO ILLUSTRATE USE OF BITWISE SHIFT OPEATORS***/
#include <stdio.h>
#include <conio.h>

main()
 {
  unsigned int x,y;
  clrscr();
  x = 128; y = 32;
  printf("\n\nBefore right shifting, x = %d",x);
  printf("\nBefore left shifting, y = %d",y);
  getch();
  x = x >> 2;
  y = y << 3;
  printf("\n\nAfter right shifting x by 2, x = %d",x);
  printf("\nAfter left shifting y by 3, y = %d",y);
  getch();
 }
```

Output of the program:

```
Before right shifting, x = 128

Before left shifting, y = 32
```

(C) Ternary Operator:

- It takes three operands.
- There is only one such operator in ‘C’ and it is called the ‘**Conditional Operator**’.
- It uses character pair **? :**
- Its general syntax is

test_exp ? exp1 : exp2

where, **test_exp** is a test condition, usually a relational expression like a > b

exp1 and **exp2** can be any valid arithmetic expressions or variables or constants.

- The **? :** operator pair works as follows:
  - If the result of the test_exp is TRUE, exp1 is evaluated and the value of exp1 is the value of conditional operation.
  - If the value of test_exp is FALSE, exp2 is evaluated and the value of exp2 is the value of the conditional operation.

Examples:

(1) m = x > y ? a : b – 146;

if x > y is TRUE, the value of ‘a’ is assigned to ‘m’,

or if x > y is FALSE, the value of ‘b–146’ is assigned to ‘m’.

(2) flag = (c == ‘y’ || c == ‘Y’) ? 1 : 0;

if (c == ‘y’ || c == ‘Y’) is TRUE, 1 is assigned to ‘flag’

or if (c == ‘y’ || c == ‘Y’) is FALSE, 0 is assigned to ‘flag’.

```
/***THE USE OF CONDITIONAL OPERATOR***/
#include <stdio.h>
#include <conio.h>
main()
 {
  int a,b,min,max;
  clrscr();
  printf("\n\nEnter two integer numbers:");
  scanf("%d %d",&a,&b);
  printf("\n\na = %d      b = %d",a,b);
  getch();
  max = a > b ? a : b;
  min = a < b ? a : b;
  printf("\n\nMaximum of a and b is %d",max);
  printf("\nMinimum of a and b is %d",min);
  getch();
 }
```

Output of the program:

```
Enter two integer numbers: 23 56

a = 23     b = 56
```

(D) Special Operators:

(1) The sizeof() Operator:

- The **sizeof()** operator returns the size (number of bytes) of the operand.
- The operand may be a constant, variable or any valid data-type.
- The operand is written within the parentheses of the sizeof operator.
- It is commonly used to determine the lengths of arrays and structures when their sizes are not known to the programmer.
- It is also used to allocate memory space dynamically to variables during the execution of the program.

Examples: a = sizeof (int);

y = sizeof (avg);

/****USE OF SIZEOF() OPERATOR****/

```
#include <stdio.h>

#include <conio.h>

main()
 {
  int x;
  float y;
  char ch = 'y';
  clrscr();
  x = 10; y = 100.0;
  printf("\n\nSize of x = %d",sizeof(x));
  printf("\nSize of y = %d",sizeof(y));
  printf("\nSize of ch = %d",sizeof(ch));
  printf("\nSize of double = %d",sizeof(double));
  getch();
 }
```

Output of the program:

```
Size of x = 2
Size of y = 4
```

(2) The Comma Operator:

- The comma operator can be used to link the related expressions together.
- A comma linked list of expressions are evaluated left to right and the value of the right most expression is the value of the combined expression.

  Examples:

  (1) value = (x = 10, y = 5, x+y); first assigns the value 10 to **x**, then assigns 5 to **y**, and finally assigns 15 (i.e., 10+5) to **value**.

  (2) temp = a, a = b, b = temp; the comma operator is also used to exchange the values stored in two memory locations.

(3) if(n1 > n2) temp = n1, n1 = n2, n2 = temp;

- It is also used in for loops
  to initialize two variables simultaneously and

  also increment or decrement two variables simultaneously.

Examples:

(1) for(n = 1, m = 10; n <= m; n++, m++)
(2) for(i = 0; i < 10; k--, ++i)

- The comma operator can also be used in while loop statements.

Examples:

(1) while(r = pnum % z, r != 0)
(2) while(ch = getchar(), ch == 'y')

```
/****USE OF COMMA OPERATOR****/
#include <stdio.h>
#include <conio.h>
main()
 {
  int a,b,temp;
  clrscr();
  b = (a = 20,a + 10);
  printf("\n\nBefore swapping, a = %d & b = %d",a,b);
  getch();
  temp = a, a = b, b = temp;
  printf("\nAfter swapping, a = %d & b = %d",a,b);
  getch();
 }
```

Output of the program:

```
Before swapping, a = 20 & b = 30

After swapping, a = 30 & b = 20
```

Shorthand Assignment Operators:

- Shorthand assignment operators associated with arithmetic operations have already been seen.
- The bitwise operators can also be written in shorthand form.

The shorthand arithmetic operators and bitwise operators:

Operator	Assignment Expression	Shorthand Assignment
+ (plus)	a = a + b	a += b
- (minus)	a = a – b	a -= b
* (asterisk)	a = a * b	a *= b
/ (slash)	a = a / b	a /= b
% (percentage)	a = a % b	a %= b
& (bitwise AND)	a = a & b	a &= b
| (bitwise OR)	a = a | b	a |= b
^ (XOR)	a = a ^ b	a ^= b
<< (left shift)	a = a << b	a <<= b
>> (right shift)	a = a >> b	a >>= b

Data type conversion:

- The processes of changing the data type of a variable only in one particular statement, say change **int** to **float** or **float** to **int** is known as **data type conversion** or **type casting**.
- The general form of type casting is **(data type)variable**

Example:

```
int a = 3;

float sum;

sum = 20/a;

……………………………
```

Value of 'sum' is 6.00000

```
int a = 3;

float sum;

sum = 20/(float)a;

……………………………
```

Value of 'sum' is 6.666666

Precedence and Associativity of C operators:

<table>
<tr><th>Operator</th><th>Description</th><th>Associativity</th><th>Precedence</th></tr>
<tr><td>()
[]</td><td>Function call
Array references</td><td>L to R</td><td>1</td></tr>
<tr><td>+
-
++
--
!
~
*
&
sizeof()
(type)</td><td>Unary plus
Unary minus
Increment
Decrement
Logical negation
Ones complement
Pointer reference
Address
Size of an object
Type cast (conversion)</td><td>R to L</td><td>2</td></tr>
<tr><td>*
/
%</td><td>Multiplication
Division
Modulus</td><td>L to R</td><td>3</td></tr>
<tr><td>+
-</td><td>Addition
Subtraction</td><td>L to R</td><td>4</td></tr>
<tr><td><<
>></td><td>Bitwise left shift
Bitwise right shift</td><td>L to R</td><td>5</td></tr>
<tr><td><
<=
>
>=</td><td>Less than
Less than or equal to
Greater than
Grater than or equal to</td><td>L to R</td><td>6</td></tr>
<tr><td>==
!=</td><td>Equal to
Not equal to</td><td>L to R</td><td>7</td></tr>
<tr><td>&</td><td>Bitwise AND</td><td>L to R</td><td>8</td></tr>
<tr><td>^</td><td>Bitwise XOR</td><td>L to R</td><td>9</td></tr>
<tr><td>|</td><td>Bitwise OR</td><td>L to R</td><td>10</td></tr>
<tr><td>&&</td><td>Logical AND</td><td>L to R</td><td>11</td></tr>
<tr><td>||</td><td>Logical OR</td><td>L to R</td><td>12</td></tr>
<tr><td>? :</td><td>Conditional expression</td><td>R to L</td><td>13</td></tr>
<tr><td>=
*= /= %=
+= -= &=
^= |=
<<= >>=</td><td>Assignment operators</td><td>R to L</td><td>14</td></tr>
<tr><td>,</td><td>Comma operator</td><td>L to R</td><td>15</td></tr>
</table>

Mathematical functions:

- C provides a large number of mathematical functions which readily calculate the values of trigonometric, hyperbolic and other functions.
- All these functions are defined in the header file **math.h**.
- Some of the most commonly used mathematical functions are:

Function		Return type	Meaning
Trigonometric	acos(x)	double	Arc cosine of x ($\cos^{-1}$ x)
	asin(x)	double	Arc sine of x ($\sin^{-1}$ x
	atan(x)	double	Arc tangent of x ($\tan^{-1}$x)
	atan2(x,y)	double	Arc tangent of (x/y) [$\tan^{-1}$(x/y)]
	cos(x)	double	Cosine of (x)
	sin(x)	double	Sine of (x)
	tan(x)	double	Tangent of (x)
Hyperbolic	cosh(x)	double	Hyperbolic cosine of x
	sinh(x)	double	Hyperbolic sine of x
	tanh(x)	double	Hyperbolic tangent of x
Other functions	abs(x)	int	Absolute value of x
	ceil(x)	double	x rounded up to nearest integer
	exp(x)	double	e to the power of x (e^x)
	fabs(x)	double	Absolute value of x
	floor(x)	double	x rounded down to nearest integer
	fmod(x,y)	double	Remainder of x/y
	log(x)	double	Natural log of x, x > 0 ($\log_e$x)
	log10(x)	double	Base 10 log of x, x > 0 ($\log_{10}$x)
	pow(x,y)	double	x to the power of y (x^y)
	sqrt(x)	double	Square root of x, x >= 0

INPUT – OPUTPUT STATEMENTS

- Reading, processing and writing are the three essential functions of a computer.
- Every computer program has to take some data as **input** and write/print/display the processed data as **output**.

There are two methods of data input:

1. Non-Interactive method:

Values are assigned to the variables in the program itself.

Example:

```
main()
 {
    int x, y = 20;
                                  Initialization
    float avg, marks = 0.0;
    . . .                                         Non-interactive
    . . .                                         method of data input.
    x = 21;
                        Assignment
    avg = 18.5;
    . . .
    . . .
 }
```

2. Interactive Method:

- Data is supplied to the computer by the user through standard input device like the key board.
- Examples are the input functions like **scanf**, **getchar**, **gets**, etc. of ‘C’ which are used to read data into the computer.

INPUT – OUTPUT FUNCTIONS:

- ‘C’ is a functional programming language. i.e., a ‘C’ program is constructed by making use of functions.
- ‘C’ provides a set of functions to perform the basic input/output (I/O) operations.
- All these I/O functions are stored in a header file by name **standard input output library** and is denoted by **stdio.h**
- We attach this header file to our C program by using the pre processor directive **`#include <stdio.h>`** at the beginning of the program.
- **`#include <stdio.h>`** tells the compiler to search for the file name **`stdio.h`** and place its contents at this point in the program. The contents of the header file become a part of the source code when it is compiled.
- Some of the standard I/O functions frequently used in ‘C’ are:

`scanf()`	`printf()`	`putchar()`
`getchar()`	`getch()`	`getche()`
`gets()`	`puts()`	

- Note that the functions `getch()` and `getche()` are defined in another header file by name **`conio.h`**

There are two types of I/O functions in ‘C’:

1. **Formated I/O functions:** These enable the user to specify the type of data and the way in which it should be read or written out.
2. **Unformated I/O functions:** Using these types of functions, the user cannot specify the type of data and the way in which it should be read or written out.

	Input function/s	**Output function/s**
Formatted	`scanf()`	`printf()`
Unformatted	`getchar()`, `getch()`, `gets()`, `getche()`, `etc.`	`putchar()`, `puts()`, `etc.`

FORMATTED INPUT:

- It refers to the input of one or more data types arranged in a particular format.

  For example, consider `23.06` `192` `Nitte`

  - A single line consists of <u>three pieces of data</u> arranged in a particular format.
  - The first part `23.06` must be read into a <u>float</u> variable.
  - The second part `192` must be read into an <u>integer</u> variable
  - The third part “`Nitte`” must be read into a <u>string</u> variable.
  - Such data must be read according to the <u>sequence</u> of their appearance.

- This can be done using the input function **`scanf()`** in ‘C’.
- For the above example the **`scanf()`** function is written as:

```
scanf("%f %d %s",&weight,&height,name);
```

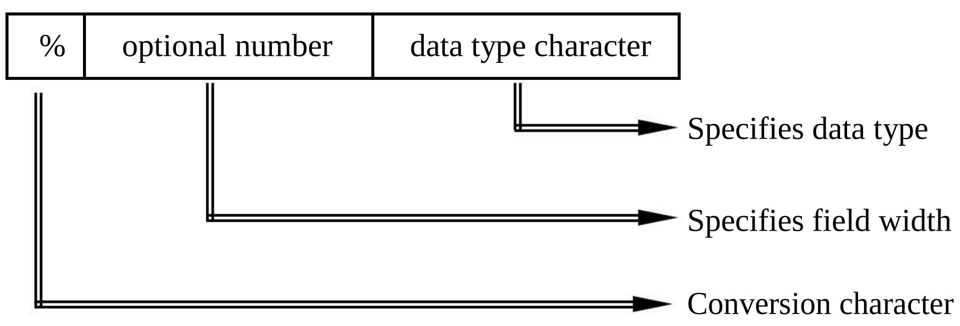
Syntax of `scanf()` function:

```
scanf("control string", address_list);
                OR
scanf("control string", &var1, &var2,…………&varn);
```

“control string” contains one or more <u>character groups</u> (or <u>field specifiers</u>) which direct the interpretation of input data.

address_list OR **&var1, &var2,…………..&varn** specify the address locations of the variables where the data is stored.

Each <u>character group</u> (field specifier) starts with a % symbol.



Without the optional number which specifies the field width, the character group format is

%	data type character

The table below shows a list of the character groups (or field specifiers) commonly used:

Character group	Meaning
%c	Read a single character
%d	Read a decimal integer
%e	Read a floating point number
%f	Read a floating point number
%g	Read a floating point number
%h	Read a short integer
%i	Read a decimal or hexadecimal or octal integer
%o	Read an octal number
%p	Read a pointer
%s	Read a string
%u	Read an unsigned integer
%x	Read a hexadecimal number

Examples of `scanf()` functions:

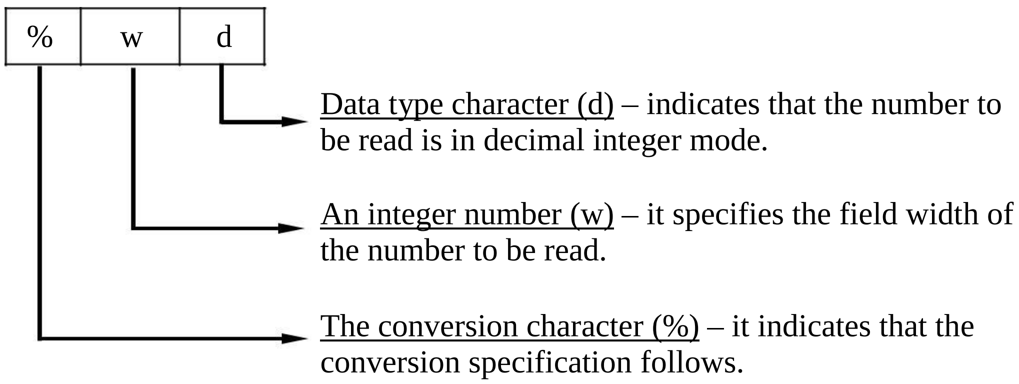
```
scanf("%d%f%c", &n1,&n2,&ch);
scanf("%d,%f,%c",&num,&avg,&c1);
scanf("%d   %f   %s",&a,   &   total,  msg);
```

Rules that govern the syntax of `scanf()`:

- Control string must be enclosed with double quotes.
- For every input variable there must be one character group.
- Multiple number of character groups are allowed in a control string. They must be separated by blank spaces.
- Each input variable must in the address_list must be preceded by an ampersand(&) symbol.
- White spaces may be included in the address_list, but all variables in the address list must be separated by commas.
- Address_list must not be enclosed within double quotes.
- The number of character groups, data type and sequence in the control string should match those of the variables in the address_list.
- A comma should separate the control string and the address_list.

Reading Integer numbers:

The character group (or the field specifier) for reading the integer number is:



Consider the following example:

```
scanf("%2d %5d",&num1,&num2);
```

- When the computer executes this statement, it waits for the user to enter values for the variables `num1` and `num2`.
- Let the values entered be: 50   31426.

50 will be assigned to `num1` and 31426 to `num2`.

- Suppose the values entered are: 31426 50

  `num1` will be assigned with 31 (because of the field width %2d)

  `num2` will be assigned with 426 (unread part of 31426)

  The value 50 that is unread will be assigned to the first variable in the next **`scanf()`** statement.

- These kinds of errors can be eliminated if we use <u>character groups</u> with out specifying the field width (w).

  Thus the statement `scanf("%d %d",&num1,&num2);` will read the data 3142650 correctly and assign 31426 to `num1` and 50 to `num2`.

- If we enter a floating point number instead of an integer, the fractional part may be ignored and **`scanf()`** may skip reading further input.

- In place of the optional field width specifier (w) if we use a **asterisk *** symbol, that particular input field will be skipped.

  For example, for the input statement `scanf("%d %*d %d",&a,&b,&c);` if we enter 123 45 97, 123 will be assigned to **a** and 97 will be assigned to **b**, <u>45 will not be assigned to **b**</u> and will be skipped. **garbage** value will be assigned to **c**

- The data type character '**d**' may be preceded by the letter '***l***' (i.e., % ***l*****d**) to read long integers.

```
/******READING INTEGER NUMBERS**************/
#include <stdio.h>
#include <conio.h>

main()
{
  int a,b,c,x,y,z;
  int p,q,r;

  printf("\n\n\tEnter three integer
  numbers:"); scanf("%d %*d %d",&a,&b,&c);
  printf("\n\t   a=%d     b=%d     c=%d",a,b,c);

  printf("\n\n\tEnter two 4-digit integer numbers:");
  scanf("%2d %4d",&x,&y);
  printf("\n\t   x=%d     y=%d",x,y);

  printf("\n\n\tEnter two integer
  numbers:"); scanf("%d %d",&a,&x);
  printf("\n\t   a=%d     x=%d",a,x);

  printf("\n\n\tEnter a nine digit integer number:");
  scanf("%3d %4d %3d",&p,&q,&r);
  printf("\n\t   p=%d     q=%d     r=%d",p,q,r);

  printf("\n\n\tEnter two 3-digit integer numbers:");
  scanf("%d %d",&x,&y);
  printf("\n\t   x=%d     y=%d",x,y);
}
```

Output of program:

```
Enter three integer numbers:
1   2   3
a=1  b=3  c=-29730

Enter two 4-digit integer numbers:
6789    4321
x=67    y=89
Enter two integer numbers:
44   66
a=4321 x=44

Enter a nine digit integer number:
123456789
p=66    q=1234       r=567

Enter two 3-digit integer numbers:
123     456
x=89y=123
```

Reading real (floating point) numbers:

- Real numbers (both fractional and exponential notations) can be input by using either of the character groups %f %e %g

  For example, `scanf("%f %f %f",&x,&y,&z);`

  with the input data `475.89   43.21E-1      678`

  will assign `475.89` to `x`, `4.321` to `y` and `678.0` to `z`
- If the number to be read is a double precision one, then the character group **%*l*f** instead of **%f** must be used.

- A number may be skipped by using the **%*f** specification.

```
/********READING OF REAL NUMBERS**************/
#include <stdio.h>
#include <conio.h>

void main()
{
    float x,y;
    double p,q;
    clrscr();
    printf("\n\n\t   ENTER THE VALUES OF X AND Y:");
    scanf("%f %g",&x, &y);
    printf("\n\t x=%f\n\t
    y=%f",x,y); getch();
    printf("\n\n\t   ENTER THE VALUES OF P AND Q:");
    scanf("%lf %lf",&p,&q);
    printf("\n\t p=%.12lf\n\t
    q=%.10e",p,q); getch();
}
```

Output of program:

```
ENTER THE VALUES OF X AND Y:12.3456       12.3e-2
x=12.345600
y=0.123000

ENTER THE VALUES OF P AND Q:1.123456789    2.987654321
p=1.123456789000
q=2.9876543210e+00
```

Reading a single character:

- The simplest way of reading a single character from the standard input device (Keyboard) is by using the function **`getchar()`** available in the header file **`stdio.h`**.
- The syntax of the getchar function is:

  `var_name = getchar();`

  where, **var_name** is a valid variable name, initially declared as `char` type.
- When this statement is encountered, the computer waits until a key is pressed and then assigns this character as a value to the **getchar** function.

  For example,

  ```
  char ch;
  ch = getchar();
  ```

  Suppose we enter the character '`y`' through the keyboard, '`y`' is assigned to `ch`.
- Since **getchar** is a function, it is used with a set of parenthesis **`()`**
- Other functions that are used to read single variables are (available in **`conio.h`**):

  `getch():` Enables the user to enter only one character through the keyboard without pressing the enter key.

  `getche():` Enables the user to enter only one character through the keyboard without pressing the enter key, and will **echo** (display on monitor) the character typed in. (The last letter 'e' in **`getche()`** stands for echo)
- The **getchar** function when executed waits until any character of the keyboard is keyed in followed by pressing the ENTER (`\n`) key. Only after ENTER key is pressed, execution is returned to the next statement of program.
- The **getchar** function echoes (displays on monitor) the character that has been keyed in.
- We may use the **`scanf()`** function also to read a single character. For the above example the use of **`scanf()`** would be:

  ```
  char ch;
  ```

```
scanf("%c",&ch);
```

```
#include <stdio.h>
#include <conio.h>
void main()
{
 char ans;
 clrscr();
 printf("\n\n\tWould you like to know my
 name?"); printf("\n\tEnter Y for YES and N for
 NO:"); ans=getchar();
 if(ans == 'Y' || ans == 'y')
    {
     printf("\n\n\tMy name is BUSY BEE...!!!");
     getch();
    }
 else
    {
     printf("\n\n\tYou are good for nothing...!!!");
     getch();
    }
 }
```

Output of the program:

1. `Would you like to know my name?`
   `Enter Y for YES and N for NO:` Y
   `My name is BUSY BEE...!!!`

2. `Would you like to know my name?`
   `Enter Y for YES and N for NO: N`

```
You are good for nothing...!!!
```

Reading Character Strings:

- The format of the character group used for reading a string is

- The corresponding argument in the address_list must be a pointer to one dimensional array of characters.
- Suppose we want to read the string "**Handsome**" and assign it to a string variable **name**

```
char name[20];
scanf("%10c",name);   OR   scanf("%s",name);
```

- Instead of the character group `%10c` if `%6c` is used, then only first 6 characters of `Handsome` i.e., `Handso` will be assigned to `name`.
- Suppose for the above first **scanf** statement we enter `Balaguru Swamy`, only first 10 characters will be stored in `name` i.e., `Balaguru S`

  Whereas with the second **scanf** statement, only `Balaguru` will be stored in `name`. (i.e., when `%s` is used, if white space is encountered, **scanf** will terminate)
- 'C' supports some special character groups for string variables only. They are

Special character groups for strings	**Meaning**
`%[characters]`	• Only the characters specified in the square brackets are permissible in the string. • If any other character is tried to enter, the string is terminated by putting a NULL constant.
`%[^characters]`	• The characters specified in the square brackets after the carot (^) symbol are not permitted. • The reading of the string will get terminated when one of these characters are encountered.

```
#include <stdio.h>
#include <conio.h>
void main()
{
 int no;
 char name1[15],name2[15],name3[15];
 printf("\n\n\tEnter serial number and name1:");
 scanf("%d %15c",&no,name1);
 printf("\n\t%d
 %15s",no,name1); getch();
 printf("\n\n\tEnter serial number and name2:");
 scanf("%d %s",&no,name2);
 printf("\n\t%d
 %15s",no,name2); getch();
 printf("\n\n\tEnter serial number and name3:");
 scanf("%d %15s",&no,name3);
 printf("\n\t%d
 %15s",no,name3); getch();
}
```

Output of Program:

Output 1:

```
Enter serial number and name1:
1        123456789012345
1        123456789012345r
Enter serial number and name2:
2        Radha Krishna
2                Radha
Enter serial number and name3:
2 Krishna
```

Output 2:

```
Enter serial number and name1:
1        123456789012345
1        123456789012345r
Enter serial number and name2:
2        RadhaKrishna
2        RadhaKrishna
Enter serial number and name3:
3         Suryakanth
3        Suryakanth
```

```
#include <stdio.h>
#include <conio.h>
void main()
{
char str[15];
clrscr();
printf("\n\n\tEnter address1:\n");
scanf("%[a-z]",str);
printf("\n\t%s",str);
getch();
flushall();
printf("\n\n\tEnter address2:\n");
scanf("%[^\n]",str);
printf("\n\t%s",str);
getch();
}
```

Output of the program:

```
Enter address1:
Karkala 574110
Karkala
Enter address2:
Karkala 574110
Karkala 574110
```

The `gets()` function:

- It is another function which is used to read a string.
- It accepts all the characters on the keyboard as input and will terminate only when the ENTER key (`\n`) is pressed.
- Example is `char add[30];`
  `gets(add);`

Program:

```
#include <stdio.h>
#include <conio.h>
void main()
{
 char add[30];
 gets(add);
 puts(add);
 getch();
}
```

Output of program:

```
NMAMIT, Nitte - 574110
```

Reading Mixed Data Types (Mixed mode Input):

- The **`scanf()`** function can be used to read more than one type of data (mixed mode).
- In such situations, the programmer should take care of the (1) **number of input variables**, (2) **data type** and (3) their **order**.
- If there is a type mismatch, **`scanf()`** function does not read the values input.
- For example, consider the **`scanf()`** statement

  `scanf("%d %c %f %s",&count,&code,&ratio,name);`

  The input values entered must be of the form

  `15 p 1.575 coffee` for successful reading of the values respectively to `count`, `code`, `ratio` and `name`.
- For the above example, on successful reading, the **`scanf()`** function will return a value 4 (i.e., the number of data types successfully read).
- Suppose the input values to the above example are of the form:

  `15   p   coffee   1.575`
  - Then, **`scanf()`** function will return a value 2 because <u>only two data types have been successfully read</u>.
  - There is **match** between the control string parameters and address_list parameters only for first two input values.
  - The 3rd data was expected to be a floating type number, but a string data type has been encountered. So **`scanf()`** <u>terminates the scan</u> soon after reading the first two data types.
- If the input values for the above **`scanf()`** statement were of the form,

  `20   150.25   motor`

  The return value would be 1 since only one data (first data) has been correctly read
- Making use of the return values, we can check the correctness of data input.
- The following program illustrates the testing for correctness of data input.

```
/*****PROGRAM TESTING CORRECTNESS OF INPUT*******/
#include <stdio.h>
#include <conio.h>

void main()
{
 int a,r; float b; char c;
 clrscr();
 printf("\n\n\tEnter the values of a, b and
 c:"); r=scanf("%d %f %c",&a,&b,&c);

 if(r==3)
     printf("\n\ta=%d   b=%f   c=%c",a,b,c);
 else
     printf("\n\tERROR IN INPUT...!!");

 getch();
}
```

Output of program:

1. `Enter the values of a, b and c:`

   `12    3.45     A`

   `a=12    b=3.45   c=A`

2. `Enter the values of a, b and`
   `c: 23 78 9`

   `a=23   b=78.000000   c=9`

3. `Enter the values of a, b and`
   `c: Y 12 67`

   `ERROR IN INPUT...!!`

4. `Enter the values of a, b and c:`

   `15.75    23   X`

```
a=15   b=0.750000   c=2
```

FORMATED OUTPUT:

- It refers to display of the processed values or results and messages on the display screen according to the format (way of appearance) as desired by the programmer.
- It is highly desirable that the messages and values must be displayed in the most legible (understandable) form.
- The **`printf()`** function is a standard formatted output function defined under the header file **`stdio.h`**.
- It's general syntax is:

```
printf("control string", var_list);
OR
printf("control string", arg1,arg2,……argn);
```

- The control string indicates how many arguments follow and what their types are. Control string consists of three types of items:
  1. Characters that will be placed on the screen as they appear
  2. Character groups (format specifiers) that define the output format for display of each item.
  3. Escape sequence (backslash constants) such as `\n`, `\t`, `\b`, etc.
- **`arg1, arg2,…….argn`** are the list of arguments (variables) whose values are formatted and printed according to the specifications of the control string.
- The general format of the character group (format specifier)used in **`printf()`** is

```
%w.p type_specifier
```

where,

w is an integer number that specifies the total number of columns of output value

p is another integer which specifies the number of digits to the right of the decimal point of the floating point number.

or it is the number of characters to be printed from a string.

Both **w** and **p** are optional.

type_specifier is the character group (format specifier) like d, f, c, s, etc.

Out put of integer numbers:

- The format specification for printing an integer number is

%wd

where,

w specifies the minimum field width for output. However is a number is greater than the specified field width, it will be printed in full overriding the minimum specification.

d specifies that the value to be printed is an integer.

- The number is written right justified in the given field width.
- Leading blanks will appear as necessary.
- Preceding **w** with a minus sign (−) will cause the number to be displayed in left justification.
- Examples :

`printf("%d",9876)`	9	8	7	6		
`printf("%6d",9876)`			9	8	7	6
`printf("%2d",9876)`	9	8	7	6		
`printf("%-6d",9876)`	9	8	7	6		
`printf("%06d",9876)`	0	0	9	8	7	6

Sample Program:

```
#include <stdio.h>
#include <conio.h>
void main() {

 int m=12345;
 long n=987654;
 clrscr();
 printf("\n\n\t%d",m);
 printf("\n\t%10d",m);
 printf("\n\t%010d",m);
 printf("\n\t%-10d",m);
 printf("\n\t%10ld",n);
 printf("\n\t%10ld",-n);
```

Output of the program:

```
12345
     12345
0000012345
12345
    987654
   -987654
```

```
 getch();
}
```

Out put of floating point numbers:

- The format specification for a floating point number in decimal notation is

`%w.pf`

- The format specification for a floating point number in exponential notation is

`%w.pe`

where,

w is an integer which specifies the minimum number of positions that are to be used for the display of the value.

p is an integer which specifies the precision i.e., the number of digits to be displayed after the decimal point.

- **w** and **p** are both optional specifications

For both the type of notations,

- The default precision is 6 decimal places.
- The negative numbers will be printed with a minus sign.
- The value when displayed, is rounded off to **p** decimal places and printed right justified in the field of **w** columns.
- Padding the leading blanks with zeros can be done by preceding **w** with a zero.
- Printing with left-justification is possible by putting a minus sign before **w**.

- A special field specification character **`"%*.*f"`** that lets the user define the field size during run-time may also be used.

For example, `printf("%*.*f",7,2,num);`

is same as `printf("%7.2f",num);`

The advantage of this format is that the values for the **width** and **precision** may be supplied during run-time, thus making the format a dynamic one.

Example: Consider the display of the number y = 98.7654 under different format specifiers.

`printf("%7.4f",y);`	9	8	.	7	6	5	4					
`printf("%7.2f",y);`			9	8	.	7	7					
`printf("%-7.2f",y);`	9	8	.	7	7							
`printf("%f",y);`	9	8	.	7	6	5	4					
`printf("%10.2e",y);`			9	.	8	8	e	+	0	1		
`printf("%11.4e",-y);`	–	9	.	8	7	6	5	e	+	0	1	
`printf("%-10.2e",y);`	9	.	8	8	e	+	0	1				
`printf("%e",y);`	9	.	8	7	6	5	4	0	e	+	0	1

```
/******PRINTING OF FLOATING POINT NUMBERS******/
#include <stdio.h>
#include <conio.h>

void main()
{
 float y = 98.7654;
 clrscr();
 printf("\n\n\t%7.4f",y);
 printf("\n\t%f",y);
 printf("\n\t%7.2f",y);
 printf("\n\t%-7.2f",y);
 printf("\n\t%07.2f",y);
 printf("\n\t%*.*f",10,2,y);
 printf("\n\n\t%10.2e",y);
 printf("\n\t%12.4e",-y);
 printf("\n\t%-10.2e",y);
 printf("\n\t%e",y);
 getch();
}
```

Output of the program:

```
98.7654
98.765404
  98.77
98.77
0098.77
     98.77

 9.88e+001
-9.8765e+001
9.88e+001
9.876540e+001
```

Printing of Single Character:

- Using the formatted output, a single character can be displayed in a desired position using the format

% w c

- The character will be <u>right justified</u> in the field of **w** columns.
- The display can be made <u>left justified</u> by placing a <u>minus sign</u> before **w**
- The default value of w is 1.

Printing of Strings:

- The format specification for printing strings is similar to that of floating point numbers.

% w . p s

- where **w** specifies the field width for display
- **p** specifies that only first p characters of the string are to be displayed.
- The display is right justified
- Consider a string consisting of 16 characters (including blanks) "BANGALORE 560010"

Specification	**Output**																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**
%s	B	A	N	G	A	L	O	R	E		5	6	0	0	1	0				
%20s					B	A	N	G	A	L	O	R	E		5	6	0	0	1	0
%20.10s											B	A	N	G	A	L	O	R	E	
%.5s	B	A	N	G	A															
%-20.10s	B	A	N	G	A	L	O	R	E											
%5s	B	A	N	G	A	L	O	R	E		5	6	0	0	1	0				

```
/****PRINTING OF CHARACTERS AND STRINGS****/
#include <stdio.h>
#include <conio.h>

void main()
{
 char x = 'A';
 char name[25] = "MAHENDRA SINGH DHONI";
 clrscr();
 printf("\n\n\tOUTPUT OF CHARACTERS\n");
 printf("\n\t%c\n\t%3c\n\t%5c",x,x,x);
 printf("\n\t%3c\n\t%c",x,x);
 getch();
 printf("\n");
 printf("\n\tOUTPUT OF STRINGS\n");
 printf("\n\t%s",name);
 printf("\n\t%25s",name);
 printf("\n\t%25.10s",name);
 printf("\n\t%.5s",name);
 printf("\n\t%-25.10s",name);
 printf("\n\t%5s",name);
 getch();
}
```

Output of the Program:

```
OUTPUT OF CHARACTERS

A
  A
    A
  A
A

OUTPUT OF STRINGS

MAHENDRA SINGH DHONI
     MAHENDRA SINGH DHONI
               MAHENDRA S
MAHEN
MAHENDRA S
MAHENDRA SINGH DHONI
```

Unformatted output of single character:

- Using unformatted output, a single character can be output by using the function **`putchar()`** available under the header file **`stdio.h`**.
- The syntax of **`putchar()`** is:

  `putchar(var_name);`

  where **`var_name`** is a **char** type variable containing a character.
- This statement displays the character contained in **`var_name`** on the display monitor.
- For example, the statements

  ```
  ans = 'Y';
  putchar(ans);
  ```

  will display the character Y on the screen.
- The statement `putchar("\n");`

  will cause the cursor to move to the beginning of the next new line.

Character Testing Functions:

- 'C' has a set of library functions which are used to test the type of character, i.e., whether a character is a lower case or upper case alphabet or a digit or printable character, etc.
- All these functions are stored in a header file by name **`ctype.h`**

Some of the Character Testing Functions	
Function	**Test**
`isalnum(c)`	Is c an alphanumeric character?
`isalpha(c)`	Is c an alphabetic character?
`isdigit(c)`	Is c a digit?
`islower(c)`	Is c a lower case letter?
`isupper(c)`	Is c an upper case letter?
`isprint(c)`	Is c a printable character?
`ispunct(c)`	Is c a punctuation mark?
`isspace(c)`	Is c a white space character?

```
/****WRITING A CHARACTER TO SCREEN****/
#include <stdio.h>
#include <conio.h>
#include <ctype.h>
void main()
{
 char c;
 clrscr();
 printf("\n\nEnter a character:\n");
 c=getchar();
 if(islower(c))
     putchar(toupper(c));
 else
     putchar(tolower(c));
```

Output of Program:

1. ```
   Enter a character:
   a
   A
   ```
2. ```
   Enter a character:
   M
   m
   ```

```
 getch();
}
```

Unformatted output of a string:

- Using unformatted output, a string can be output using the function **`puts()`** available under the header file **`stdio.h`**.
- The syntax of **`puts()`** function is

```
puts(string);
```

where, **`string`** is either a variable name containing a string or it is a string constant.

- This statement displays the string on to the display terminal and appends a new line character(**`\n`**) in the end.