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Module-1

Introduction to Computer & Programming

1.1 INTRODUCTION :

In 21st century, we are crossing the threshold of new information era in which we are developing tools that permit us to amplify human intelligence and acquire the information needed to explore new systems in area of education, research, health care, commercial business and manufacturing etc. This new information era is nothing but the **computer Era**. Here in this chapter basic fundamentals of computer system, software and hardware is described.

1.2 COMPUTER :

It is an electronic device which accept data from out side world (standard input devices) and manipulates or process it at high speed according to instruction given. It has memory to store large amount of data, can process it in accurate form with high speed by using power full processor. Computer is also called data processor because it can store, process and retrieve data when ever required. A computer system consist of six elements.

1. hardware
2. software
3. instructions or procedure or module
4. data/information
5. communication
6. people

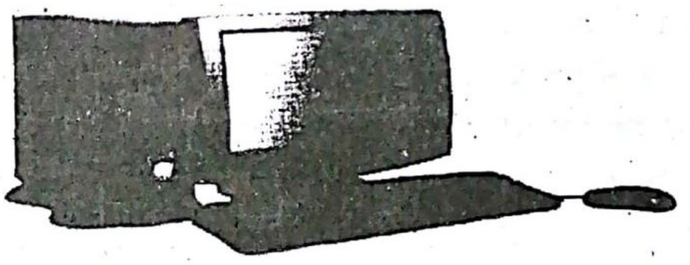

Fig 1.1 computer system

A computer can not work on its own, but work is based on some prior instructions given to it that is known as computer programming. According to instruction it perform action. A computer therefore follows a series of instructions, programmed into its memory by its user, here schematic diagram of data processing is shown in fig 1.2.

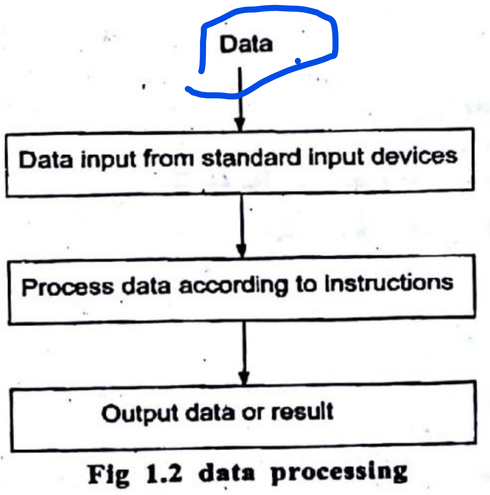

Fig 1.2 data processing

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data : fact or raw material used as input

information : process data into meaningful form.

1.3 COMPUTER SYSTEM CHARACTERISTICS OR FUNCTIONS :

1. **Speed and accuracy** : First basic reason of usage of computer is high speed. The speed is measured in clock cycle i.e. Hertz (Hz), now a days desktop are available in speed in GHz.

   In addition to its speed, computers are very accurate. The circuits in a computer having electronic parts, which do not wear and tear. Instruction are carried out without any mistake.

   Computer error caused due to incorrect input data or unreliable procedure or program, which are often referred to as a Garbage – In – Garbage – out (GIGO).

2. **Diligence and maintenance** : It is machine so it works tirelessly around 24 hrs of a day. It is also free from monotony and lack of concentration. It is best tool or machine for performing repetitive jobs and operations.

3. **Vast storage media** : It can store and process vast amount of information in very little space. Computer processing unit break this information in a form which is understandable to it and process it to put in more intelligible form. We can call back these information from its memory and use into calculation or for manipulation thus act as a vast storage media.

4. **Time factor** : Response time is greatly reduced while the total time spent in various decision making activities is reduced to minimum. Most instruction are carried out in fraction of second.

5. **Permanent** : In a computer system a very large amount of data can be stored. Data can be in the form of digits, alphabet, image, audio or video.

6. **Versatility** : Computer is capable of performing any task, by generating finite series of logical steps.

1.4 CLASSIFICATION OF COMPUTER SYSTEM :

It is classified according to principles of operation, size and number of user

- Based on electronic technology
- Based on number of users and working environment
- Based on accuracy and speed
- Based on storage requirement

They are also classified as

- Micro computer
- Mini computer
- Main frame computer
- Super computer.
- Note book computer
- Pum top computer

1.5 APPLICATION OF COMPUTER :

There are various area where computer can be used.

1. **Reservation system** (air, rail way, bus)
2. **Crime detection**
3. **Production system**
4. **Space technology**
5. **Weather forecasting**
6. **Research and science**

7. **Cost analysis**
8. **Banking system**
9. **Hotel management**
10. **Hospital management**
11. **Library management**

1.6 BASIC BLOCK DIAGRAM AND FUNCTIONS OF COMPUTER COMPONENTS : (June, 09)

Basic block diagram of computer system is drawn in fig 1.3. There are basic five components which are

1. Central processing unit (CPU) (ALU and CU)
2. Memory
3. Input device
4. Output device
5. Secondary storage device

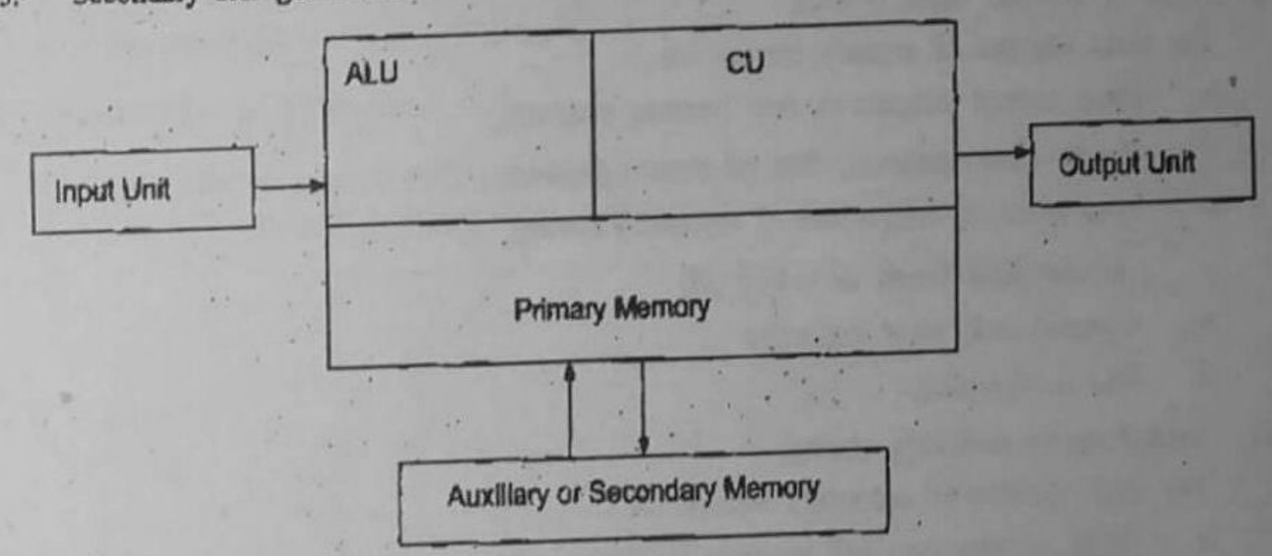

Fig 1.3 block diagram of computer system

1. **Central Processing Unit (CPU)** : The central processing unit (CPU), some times referred to as "brain" of the system, is main part of computer system that contain electronic circuitry that actually process the data. Acting on the instruction it receives, the CPU performs operation on data. It also controls the flow of data through the system, directing the data to enter the system placing data in memory and retrieving them when needed, and directing the output. CPU consists of

   1. ALU (Arithmetic logic unit)
   2. CU (Control Unit)

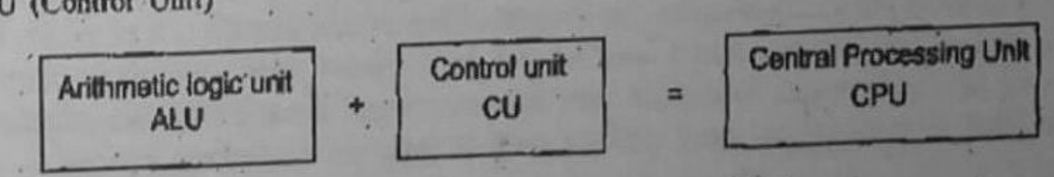

Fig 1.4 Processing outline of CPU

1. **ALU** : Here actual execution instruction take place during processing operation. It performs all arithmetic calculations and take logical decision. It can compare, count, shift or other logical activities. All such calculation and comparisons are done in this unit. It takes data from memory unit and return information (process data) to memory unit if storage require. It calculates very fast.

2. **CU** : It manages and coordinates operations of all other components of computer system. It also perform following functions.

   - It retrieve instruction or data from memory.

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- It decode instruction
- It coordinate time sequence of instruction among various component of system
- It determine requirement of storage and take action according to it.
- It also fetch instruction from main memory.

3. **Memory Unit** : The storage unit of computer system store data for following purposes.
   - Processing data and instructions
   - Storage of temporary result (intermediate data storage)
   - Permanent storage for future requirement (secondary storage)

   There are two types of storage.

   (1) Primary storage

   (2) Secondary or auxiliary storage.

   (1) **Primary storage (user RAM) :**

   The main features of primary storage are...
   - Store current program or data (running program)
   - It also store temporary data of current program.
   - Less space in comparison of secondary storage.
   - Volatile (data losses on power off)
   - Comparatively more expensive
   - Fast in operation

   (2) **Secondary or auxiliary storage :**

   The main features of secondary storage are ...
   - Used to store data and program for future usage.
   - Large capacity (GB) in comparison with primary memory
   - Slower than primary memory
   - Retain data without power
   - Cheaper than primary memory

4. **Input /Output Unit :**

Basic aim of I/O devices is to provide communication between computer and user. Input device transmit the data as a series of electrical pulses into the computer memory unit where it will be available for processing. The input devices translate data into a code be read by computer system electronic circuitry. Some input devices, such as the keyboard, enable the user to communicate directly with the machine. Other require data to be first recorded on an input medium such as paper or magnetized material.

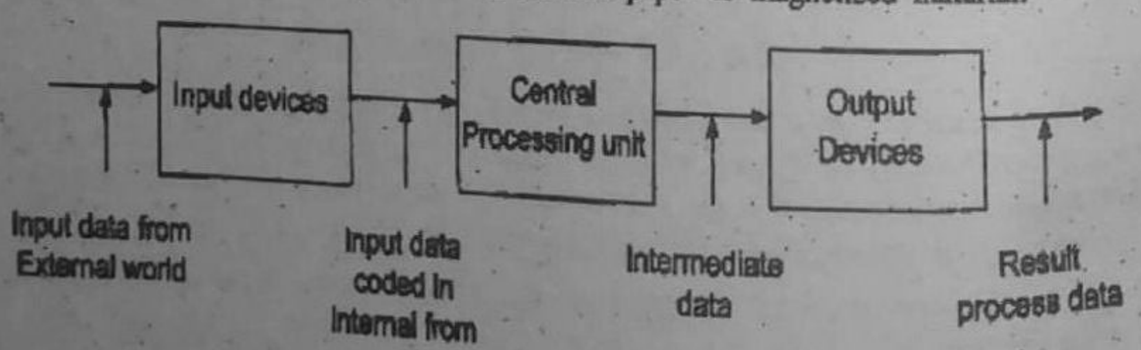

Fig. 1.5 Input/output devices processing diagram

Output devices :

Output devices supply result of processing from primary storage or secondary storage. When a program executed and the results must be made available in a human readable form. The computer system needs an output unit to communicate the processing information to the user. The output device translate processed data from a machine coded form to a form that can be read and used by people. The most common types of output devices are monitor which resembles a screen, printer prints copy from computer on paper, plotter plot diagram or figure on paper. A new type of output device is the speech synthesizer, a mechanism attached to the computer that produces verbal output sounding almost like human speech.

1.7 LIMITATION OF COMPUTER :

- computer cannot identify any input / output by itself for solving problem
- it cannot make any decision related problem, solution formula must be given.
- it can not make any decision on the base of experience.
- It can not interpret the data store in to storage media in different aspects as per situation.
- For every solution rules or procedure or sequence needed.

1.8 COMPUTER SOFTWARE :

Computer software refers to collection of programs. Program is the collection of instructions, which perform particular task and collection of programs which accomplishes application is called software.

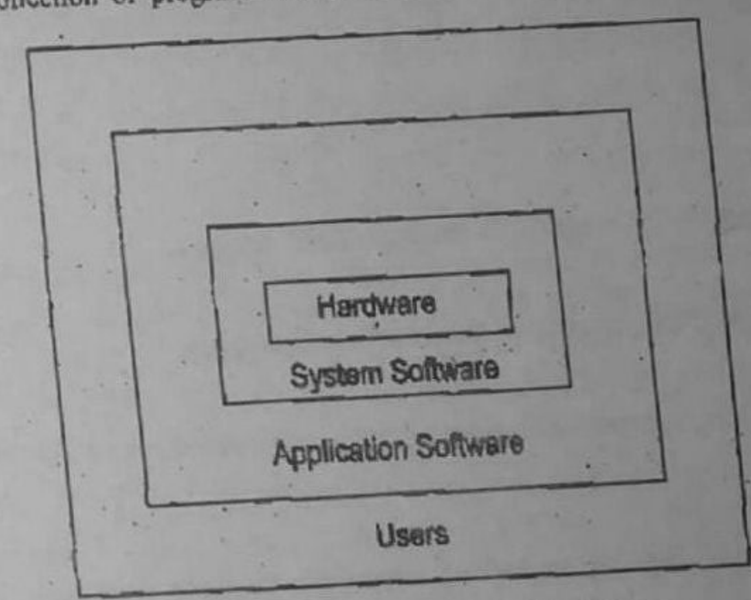

Fig. 1.6 Layer structure of software

There are basically two types of software available

1. **System software**
2. **Application software**

1. **System Software :**

System software is designed to control operation and extend the processing capabilities of computer system. They control internal computer functions. such as reading data from input device, transmit processing information to output devices, provide various facilities likes file management, Input/Output management and CPU time to user program during execution of program. The help hardware component work together and provide support for development and execution of application software. These are various system software available.

1. operating system (OS)
2. compiler
3. assembler

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4. loader
5. linker
6. editor
7. translator
8. macro processor.
9. interpreters

(1) **Operating System :**

It is a system software which manages hardware as well as interacts with user and provide different services to user program. services like memory management, I/O management, CPU management, process management. Example of OS are Vista, Windows Xp, Linux, D.O.S. etc. It is also classified as...

- single user OS
- multi user OS
- multi tasking OS
- multi programming OS
- multi threading OS
- time sharing OS
- batch processing OS
- distributed OS
- network OS
- real time OS

(2) **Compiler :**

It translates higher level program to machine level program.

(3) **Assembler :**

It translates lower level program to machine level program.

(4) **Loader :**

It loads Operating System part and object program into main memory for execution purpose. e.g. Boot strap loader.

(5) **Linker :**

Which bind symbolic code of source and library file to make executable program.

(6) **Editor :**

Used to create a program or software, also used to edit it. It may be a part of a software development package.

(7) **Translator :**

It converts one language into other. Example is compiler, assembler, interpreter.

(8) **Macro processor :**

It is used before translator, replace symbolic meaning into their equivalent code. They are also called pre-processor.

(9) **Interpreter :**

It translates line by line high level programs into low level programs.

2. **Application Software :**

A software designed for user specific need is called application software or application package e.g. library management, school management, hospital management etc.. They are developed with help of programming

language or packages. Some program direct the computer to perform specific tasks requested by user, such as printing report of customize program, mail, store result etc., such program also called application software. Application software are available from vendors. There are two types of application software available.

(1) general purpose.
(2) specific purpose software.

(1) **General purpose :**

They are designed for many task and provide many number of tasks and provides many features. e.g. Microsoft Office, PageMaker etc..

(2) **Specific purpose software :**

The packages pay roll, financial accounting, inventory control etc are some of the specific purpose softwares. The pay roll packages developed for an organization following a set of rules and may not apply to another organization as the pay calculation rules varies. The other packages developed for one organization cannot be applied directly to any other organization.

1.9 COMPUTER HARDWARE :

- It is a physical component of the computer system.
- The term hardware refers to the part of computer user can touch.
- It consists of interconnected electronic devices that control every thing the computer does
- It consists of a processor, input and output devices, memory, storage devices.
- For maintenance it require special software and some hardware tools.
- Peripherals of computer are also called hardware e.g. printer, plotter, cd, dvd, floppy disk, joy stik, key board, mouse etc.

Processor :

The role of processor is to process complex task in to meaning full form as per user requirement. It is like the brain of computer, the part that organizes and carries out instructions that come from either the user or the software. In personal computer, it is also called as microprocessor, which is fitted in to mother board of system. CPU is divided into two parts ALU and CU which are explained earlier in this chapter.

Memory : memory is classified in to two categories.

(1) primary memory
(2) secondary memory

(1) **Primary memory :** it is classified as

- Random Access memory (RAM)
- Read only memory (ROM)
- Programmable read only memory (PROM)
- Erasable programmable memory (EPROM)
- Electrically Erasable Programmable (EEPROM)

(2) **Secondary memory :** it is also called as external memory.

- hard disk (HDD)
- floppy disk
- cd
- dvd
- removable hard disk
- pen drive

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1.10 PROGRAMMING LANGUAGES :

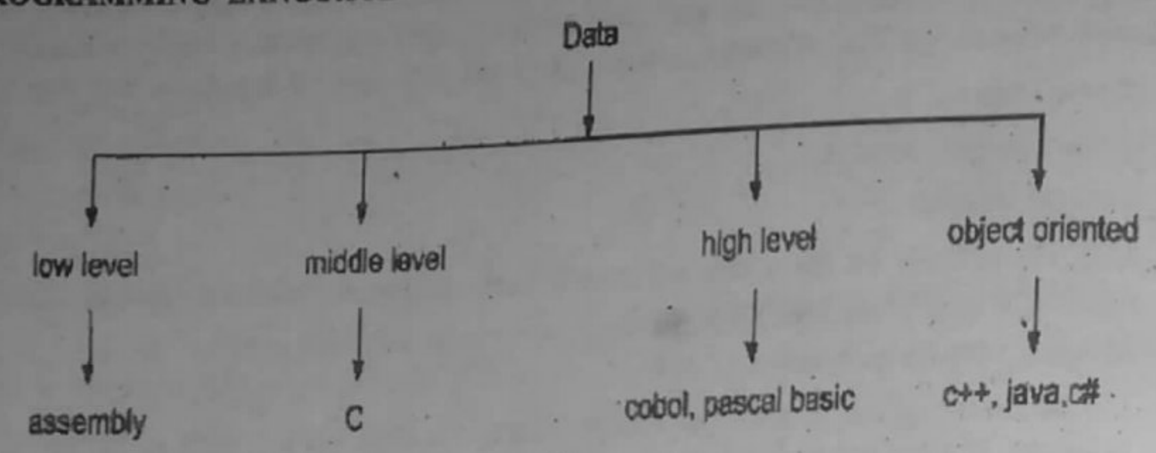

Fig.

Language is system for communicating. Written languages use symbols (characters) to build words. The entire set of words is language's vocabulary. The way in which words can be meaningfully combined are defined by the language's syntax and grammar. The actual meaning of words and combinations of words is defined by the language's semantics.

Programming language is a vocabulary and set of grammatical rules for instructing computer to perform specific tasks. It is classified as

1. Machine language or low level
2. Middle level language
3. High level language
4. Object oriented language

1. Machine or low level language :

In this language programs are written in 0's and 1's forms (binary language). which are directly understandable to computer system. Every CPU has its own machine language. It has following features.

1. Program execution is faster in comparison with others.
2. Due to direct writing in to machine code the size of code is compact and small in comparison with other languages.
3. It occupies less memory

Drawback or disadvantages

1. It require depth technical knowledge to debug program. Some time all program cannot be debug step by step.
2. Due to only two combination (0's and 1's) it is difficult to understand.

2. Assembly language :

- It is also classified as low – level language.
- This language uses mnemonics in place of 0's and 1's to represent codes.
- The word mnemonic refers to a memory aid.
- It uses symbolic addressing capabilities.
- Symbolic presentation makes easy to write program

It has following limitations.

1. Coding in this language is time-consuming.
2. This language is machine-oriented i.e. they are designed for the specific make and model of processor being used.

3. High level language :

These are the languages whose instructions closely resemble human language and mathematical notation. Unlike assembly language, programs made in this language may be used with different makes of computers with little modification. Other advantages of higher level language are :

1. Easier to learn
2. Requires less time to write
3. Provides better documentation
4. Easier to maintain

As a result, high level languages are used more often than machine or assembly languages. High level languages must also be translated in to machine language before they can be used by a computer. One of the two different language-translator program is used to translate high-level language : compiler and interpreter.

4. Object oriented Programming :

- Object oriented programming is a technique for creating common building blocks of a program called object and assembling different sets of objects to solve specific problems.
- Object oriented programming languages use a structure that defines the objects in a program along with their properties or actions. e.g. C++,JAVA.
- An object is pre-defined set of program code which will always behave so that it can be used for other application.
- Instead of writing the entire program line by line, the programmer combines the objects and writes small amount of code that is necessary finishing the program.
- A class is an abstract concept for a group of related objects. All of the objects in a class inherit the characteristics of that class. For example, if a class is automobiles, the members of that class inherit the class properties of having four wheels, an engine and doors.

Advantages	Disadvantages
1 It is Graphical User Interface (GUI), and therefore easier to use. 2. Larger program produced by the use of OOPs are very slow and use more memory and computer resources.	1. The initial development costs are very high. 2. It enables faster program development and thereby increases the programmer productivity.

⇒ **Summary of characteristics of languages :**

Sr. No.	Language	Characteristics
1	Machine language	1. machine dependent. 2. uses special codes and assignment of storage address.
2	Assembly Language	1. machine dependent 2. uses mnemonics 3. 1 to 1 language i.e. for assembly language instruction generated.
3	High-level language	1. machine independent 2. uses instructions which seem english-like. 3. 1 to many language i.e. for high level instruction, many machine language generated.

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1.11 COMPUTER GENERATION :

No.	Particulars	First	Second	Third	Fourth	Fifth
1.	Year	1949-55	1956-65	1966-75	1976-95	1996 onwards
2.	Size	Room size	Cupboard size	Desk size mini-computers	Type–writer size computers & laptops	Credit card sized computers, palmtops
3.	Density	One component per ckt	100 components per ckt	1000 components per ckt	Hundreds of thousands of components	Million of components per ckt
4.	Technology	Vacuum tubes	Transistors	Ic's	LSI	VLSI
5.	Storage	Magnetic drum, tape	Magnetic tape, disk	Magnetic disk, fdd, optical disk	Optical disk, HDD	Ultra high disk with large storage capacity
6	Operating speed	Milli-seconds 10^{-3}	10^{-6} second	10^{-9} second	10^{-12} second	10^{-15} second
7	Mean time between failure	Minutes	Days	Weeks to month	Months to year	Years

1.12 DIFFERENCES :

1. **Distinguish between compiler and interpreter.**

No.	Particular	Compiler	Interpreter
1	Scheme	Compiler scan the whole program at a time and lists out errors if any.	Interpreter scans the program line by line and stop scanning whenever error occurs.
2	Manner	Compiler converts the whole source code into object code at a time	Interpreter converts the source program line by line.
3	Source code	After compilation, source code is not required.	For every execution run source is required.
4	Speed	Execution is faster	Execution is slower
5	Object code	The object code is generated when the program is error free.	No object code file is generated.

2. **Give difference between system software and application software.**

No.	Particular	System Software	Application software
1	Purpose	System software comprise of those programs, which directs the computer.	Application software is the software developed for solving business problems.
2	Varying nature	System software varies from computer to computer	Application software varies from organization to organization.
3	Language	System software is written in low-level language/middle level language	Application software are usually written in high level language
4	Knowledge	Detail knowledge of hardware is required.	This requires detailed knowledge of organization.
5	Use	System software is used to improve the performance and maximum utilization of system resources.	Application software programs are used to improve the speed and quality of a business activity.
6	Developed by	The manufactures along with the hardware usually supply system software.	Application software is developed by individuals or supplied by software vendors as generalized application software.

3. **Give difference between Data and Information**

No.	Particulars	Data	Information
1	Meaning	**Data** is plural of word **Datum.** It is defined as the raw of facts or observations or assumptions or occurrence about physical phenomenon or business transaction.	It is the data that has been converted in to a meaningful and useful context for specific end users.
2	Organization	Data is the collection of facts, which is unorganized.	Information is an organized or classified data having a high value for its users.
3	Features	They are the objective measurements of attributes (characteristics) of entities (like people, place, thing and events)	To obtain information, data is subjected to the following : 1. data's form is aggregated, manipulated and organized 2. its content is analyzed and evaluated. 3. it is placed in a proper context for a human user.
4	Nature	Data should be accurate but need not be relevant, timely or concise.	Information must be relevant, accurate timely, concise and complete and apply to the current situation. It should be con densed into suitable length.
5	Form	It can exist in different forms. E.g. picture, sound, text or all these together	It exists as reports, in a systematic textual format, or as graphics.

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: MCQs :

1. Full form of CPU is
   (a) Control Processing Uniform (b) Control Programming Unit
   (c) Central Processing Unit (d) Central Producing Unit
2. Full form ALU is
   (a) Algorithm Legal Unit (b) Arithmetic & Logic Unit
   (c) Array Logic Unit (d) None of above
3. Which memory is volatile?
   (a) Main memory (b) Secondary memory (c) Both a and b (d) None of above
4. Which is a system software?
   (a) MS word (b) Library Management System
   (c) Student Management System (d) Compiler
5. Which language is machine independent?
   (a) Machine level (b) Assembly level (c) High level (d) None of above
6. What is known as brain of computer?
   (a) CU (b) ALU (c) CPU (d) None of above
7. What is full form of BIOS?
   (a) Basic Input Output System (b) Binary Input Output System
   (c) Bus Input Output System (d) None of above
8. BIOS is stored in
   (a) ROM (b) RAM (c) Secondary device (d) None of above
9. COBOL belongs to which generation?
   (a) First (b) Second (c) Third (d) Fourth
10. To Learn Computer, without going to classroom what will be other way
    (a) Distance Learning (b) I-Learning (c) Digital Learning (d) E-Learning
11. How to write e_mail Address ?
    (a) xyz@website.info (b) xyz@website@info (c) xyz.website.info (d) xyzwebsite.info
12. What will be a meaning of 1KB of memory
    (a) 1 Kit Bit (b) 1 Kilo Byte (c) 1 Kernel Boot (d) 1 Key Block

13. Full Form of RAM is
    (a) Random Access Memory (b) Ready Application Module
    (c) Remote Access Machine (d) Read Access Memory
14. What is Computer Virus ?
    (a) Software (b) Hardware (c) a and b (d) None of above
15. Full form of IP is
    (a) Internet Principle (b) Intercom Protocol (c) Intranet Protocol (d) Internet Protocol
16. What will be extension of Web Page's file ?
    (a) .xls (b) .3gp (c) .html (d) .ppt
17. Which of the following you will find on an inkjet printer?
    (a) It has an ink ribbon (b) It has an ink cartridge
    (c) It has high voltage power supply (d) It uses toner powder
18. Why is it important to keep Windows updated using the Windows update website or automatic updates?
    (a) To keep your system secure and to install critical updates.
    (b) To keep your system fast.
    (c) To keep your system optimized for the new game.
    (d) To keep your system protected from overheating.
19. Which protocol is used to display web pages?
    (a) SNMP (b) SMPT (c) Telnet (d) HTTP
20. In Microsoft Excel, you can use horizontal and vertical scroll bar to
    (a) Split a worksheet to two panes (b) edit the contents of a cell
    (c) view different rows and columns (d) view different worksheet
21. The system unit of personal computers typically contains all of the following except
    (a) Microprocessors (b) Disk controller (c) Serial interface (d) Modem
22. Which of the following is a read only memory storage device
    (a) Floppy disk (b) CD–ROM (c) Hard disk (d) None of these
23. Software required to run the hardware is known as
    (a) Task Manager (b) Task Bar (c) Program Manager (d) Device Driver
24. Which the following is application software?
    (a) Compiler (b) Power Point (c) Debugger (d) None of the above
25. Which of the programming language is said to be machine independent language?
    (a) High Level Language (b) Machine Language
    (c) Assembly Language (d) All the Above
26. Which of the following is smallest Network?
    (a) MAN (b) LAN (c) WAN
27. FTP stands for
    (a) File Transport Protocol (b) File Transfer Protocol
    (c) Folder Transfer Protocol
28. When a key is pressed on keyboard, which standard is used for converting the keystroke into the corresponding bits
    (a) ANSI (b) ASCII (c) EBCDIC (d) ISO
29. Which one is input device?
    (a) Monitor (b) Keyboard (c) CPU (d) Printer

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30. Which part of CPU perform calculations and make decision
    (a) Alternate Logic Unit (b) Arithmetic Logic Unit
    (c) Arithmetic Local Unit (d) Alternate Local Unit
31. What type of memory is volatile ?
    (a) Cache (b) ROM (c) RAM (d) Hard Drive
32. With regards to Email Addresses
    (a) they must always contain an @ symbol (b) they are case sensitive
    (c) they can never contain space (d) All of above
33. Which of the following is a part of primary memory of computer ?
    (a) PROM (b) CD-ROM (c) Pen-drive (d) Floppy Disk
34. Which protocol is used to transfer files on internet ?
    (a) HTTP (b) SMTP (c) FTP (d) Telnet
35. Microprocessor of computer system is a part of :-
    (a) Memory (b) Input Device (c) Output Device (d) Processing Unit
36. Which is not a font style in MS-Word
    (a) Bold (b) Superscript (c) italic (d) Regular
37. With which of the following all formulas in excel starts?
    (a) / (b) * (c) $ (d) =
38. Which of the following is not one of PowerPoint view?
    (a) Slide show view (b) Slide view (c) Presentation view (d) Outline view
39. In the evaluation of a computer language, all of the following characteristics should be considered except?
    (a) application oriented features (b) efficiency
    (c) readability (d) hardware maintenance costs
40. Keyboard is the type of device
    (a) Input (b) Pointing (c) Output (d) Sound
41. A document or image can be scanned in to digital form by using
    (a) Marker (b) Printer (c) Light pen (d) Scanner
42. Operating system is installed on
    (a) Hard Disk (b) Cache memory (c) Mother Board (d) None of these
43. Recycle bin is used for
    (a) To store backup file (b) To restore deleted file/folder
    (c) To store most frequently used files (d) All the above
44. The process a user goes through to begin a computer system.
    (a) Log out (b) Log in (c) Log off (d) None of these
45. Which among following is not necessary for working of a standalone computer?
    (a) RAM (b) Hard Drive (c) Operating System (d) LAN card
46. Which protocol is used to transfer files on Internet?
    (a) HTTP (b) FTP (c) SMTP (d) Telnet
47. In Microsoft Excel, you can use the horizontal and vertical scroll bar to
    (a) Split a worksheet in two panes (b) edit contents of a cell
    (c) view different rows and columns (d) view different worksheet

48. Full form of ROM is
    (a) Random Only Memory (b) Read Only Memory
    (c) Read Once Memory (d) None of above

: ANSWERS :

1. (c)	2. (b)	3. (a)	4. (d)	5. (c)	6. (c)	7. (a)
8. (a)	9. (c)	10. (d)	11. (a)	12. (b)	13. (a)	14. (a)
15. (d)	16. (c)	17. (b)	18. (a)	19. (d)	20. (c)	21. (d)
22. (b)	23. (d)	24. (b)	25. (a)	26. (b)	27. (b)	28. (b)
29. (b)	30. (b)	31. (c)	32. (d)	33. (a)	34. (c)	35. (d)
36. (d)	37. (d)	38. (b)	39. (d)	40. (a)	41. (d)	42. (a)
43. (b)	44. (b)	45. (d)	46. (b)	47. (c)	48. (b)	

LONG QUESTION/ANSWERS

1. **Draw block diagram computer and explain each block.**

Ans. :

Here, Basic block diagram of computer system is drawn in **fig a**. There are five Basic components, which are ...

1. Central processing unit (CPU) (ALU and CU)
2. Memory
3. Input device
4. Output device
5. Secondary storage device

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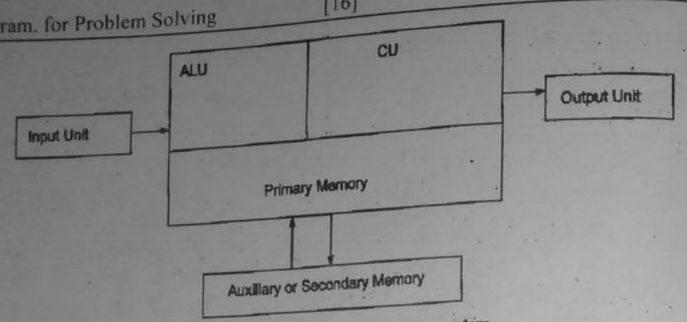

Fig a Block diagram of computer system

1. **Central Processing Unit (CPU) :**

The central processing unit (CPU), some times referred to as "**brain** " of the system, is main part of computer system that contain electronic circuitry that actually process the data. Acting on the instruction it receives, the CPU performs operation on data. It also controls the flow of data through the system, directing the data to enter the system placing data in memory and retrieving them when needed, and directing the output.

CPU consists

1. ALU (Arithmetic logic unit)
2. CU (Control Unit)

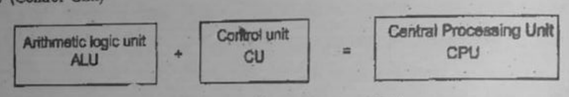

Fig b Processing outline of CPU

(1) ALU :

Here actual execution instruction take place during processing operation. It performs all arithmetic calculations and take logical decision. It can compare, count, shift or other logical activities, all such calculation and comparisons are done in this unit. It takes data from memory unit and return information (process data) to memory unit if storage require.

(2) CU :

It manages and coordinates operations of all other components of computer system. It also perform following functions.

- It retrieve instruction or data from memory.
- It decode instruction
- It coordinate time sequence of instruction among various component of system.
- It determine requirement of storage and take action according to it.
- It also fetch instruction from main memory.

2. **Memory Unit :**

The storage unit of computer system store data for following purposes.

- Processing data and instructions
- Storage of temp. result (intermediate data storage)
- Permanent storage for future requirement (secondary storage)

There are two types of storage.

1 : primary storage

2 : secondary or auxiliary storage.

(1) Primary Storage (user RAM) :

The main functions of primary storage are...

- Store current program or data (running program)
- It also store temp data of current program.
- Less space in comparison of secondary storage.
- Volatile (data losses on power off)
- Comparatively more expensive
- Fast in operation

(2) Secondary or Auxiliary Storage :

The main functions of secondary storage are...

- Used to store data and program for future usage.
- Large capacity (GB) in comparison with primary memory
- Slower than primary memory
- Retain data without power
- Cheaper than primary memory

3. **Input/Output Unit :**

Basic aim of computer system to provide communication between computer and user. Input device transmit the data as a series of electrical pulses into the computer memory unit where it will be available for processing. The input devices translate data into a code be read by computer system electronic circuitry. Some input devices, such as the keyboard, enable the user to communicate directly with the machine. Other require data to be first recorded on an input medium such as paper or magnetized material. The travel only in one direction i.e. from input device to the CPU.

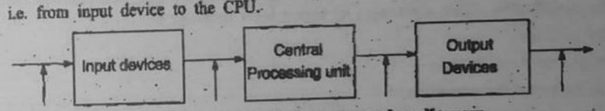

Fig c Input/output devices processing diagram

Output devices :

Output devices supply result of processing from primary storage or secondary storage. When a program executed and the results must be made available in a human readable form. The computer system needs an output unit to communicate the processing information to the user. Te out device translate processed data from a machine coded form to a form that can be read and used by people. The most common types of output devices are monitor which resembles a screen, printer prints copy from computer on paper, plotter plot diagram or fig on paper. A new type of output device being developed now is the speech synthesizer, a mechanism attached to the computer that produces verbal output sounding almost like human speech.

2. **Describe various types of computer languages and mention its advantages and disadvantages.**

Ans. :

Programming language is a vocabulary and set of grammatical rules for instructing computer to perform specific tasks. It is classified as

1. Machine language or low level
2. Middle level language
3. High level language
4. Object oriented

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1. **Machine or low level language :**

In this language programs are written in 0's and 1's forms (binary language). which are directly under stand able to computer system. Every CPU has its own machine language. It has following features.

1. program execution is faster in comparison with others.
2. due to direct writing in to machine code the size of code is compact and small in comparison with other languages.
3. it occupies less memory

Drawback or disadvantages

1. It require depth technical knowledge to debug program. Some time all program cannot be debug step by step.
2. Due to only two combination (0's and 1's) it is difficult to understand.

1. **Assembly language :**

- It is also classified as low – level language.
- This language uses mnemonics in place of 0's and 1's to represent codes.
- The word mnemonic referrers to a memory aid.
- It uses symbolic addressing capabilities.
- Symbolic presentation makes easy to write program

It has following limitations

1. Coding in this language is time-consuming
2. This language is machine-oriented i.e. they are designed for the specific make and model of processor being used.

3. **High level language :**

These are the languages whose instructions closely resemble human language and mathematical notation. Unlike assembly language, programs made in this language may be used with different makes of computers with little modification. Other advantages of higher level language are :

1. easy to learn
2. require less time to write
3. provide better documentation
4. easy to maintain

As a result, high level languages are used more often than machine or assembly languages. High level languages must also translated in to machine language before they can be used by a computer. One of the two different language-translator program is used to translate high-level language : compiler and interpreter.

4. **Object oriented Programming :**

- Object oriented programming is a technique for creating common building blocks of a program called object and assembling different sets of objects to solve specific problems.
- Object oriented programming languages use a structure that defines the objects in a program along their properties or actions. e.g. C++,JAVA
- Instead of writing the entire program line by line, the programmer combines the objects and writes small amount of codes that is necessary finishing the program.
- A class is an abstract concept for a group of related objects. All of the objects in a class inherit the characteristics of that class. For example, if a class is automobiles, the members of that class inherit the class properties of having four wheels, an engine and doors.

Advantages :

1. It is Graphical User Interface (GUI), and therefore easier to use.
2. It enables faster program development and thereby increases the programmer productivity

Disadvantages :

1. The initial development costs are very high
2. Larger program produced by the use of OOPs are very slow and use more memory and computer resources.

: SHORT QUESTIONS :

1. **List the basic components of a computer**

⇒ Basic components are CPU, Memory, Input Device, Output Device, Secondary storage device.

2. **What is an Operating System?**

⇒ Operating System is a system software which manages hardware and interacts with user to provide different services such as memory management, I/O management, Process management etc.

3. **List high level programming languages.**

⇒ Pascal, COBOL, Fortran, Java, C, C++ etc.

4. **List object oriented programming languages.**

⇒ C++, Java, C# etc.

5. **What is compiler?**

⇒ Compiler is system software which compiles the source program and generates and object code. Object code only is sufficient to create executable file and run the program.

6. **What is application software?**

⇒ Software designed for user specific need is called application software. Library management system, Payroll management system, School management system, Inventory management system are some of examples of application software.

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Module-2

Flowcharts & Algorithms

2.1 INTRODUCTION :

In chapter 1, we learned about computer fundamentals. In this chapter we have discussed tools which can be used to develop logic of program before writing any program. Flowcharts & Algorithms are example of such tools, which are used for development of software in C & C++. These provides convenience in development of programs.

2.2 PROBLEM SOLVING TECHNIQUES :

The problem solving technique is used for solving the problem. When any problem is to be solved with help of computer programming language, computer cannot solve this problem by its own way, it require to follow following steps.

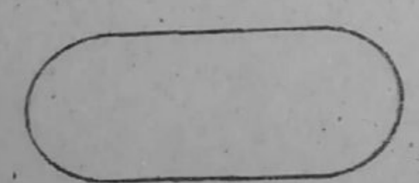
1. Problem definition
2. Analysis of problem
3. Find out input and output if required
4. Choose appropriate tools to solve problem (algorithm or flowchart)
5. Choose appropriate control structure for developing program(code design)
6. Run and debug the program (error finding)
7. Verify the output as per definition

Let us start first with flowchart, how to develop logic of program.

2.3 FLOWCHART :

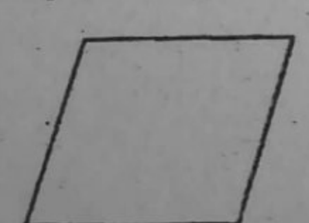
A **Flowchart** is graphical or diagrammatical representation of sequence of any problem to be solved by computer programming language. It is used before writing any program. It is also used to correct and debug a program flow after coding part is completed. Through flowchart it is easy to understand the logic and sequence of problem steps. After drawing flowchart it becomes easy to write any program. There are various standard symbols available to represent logic of problem which are...

1. Start and Stop :



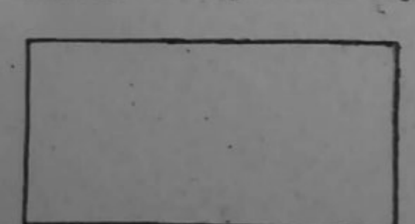
Used to start and stop or end flow chart.

2. Input / Output :



Used for input and output operation

3. Process or expression representation :



used to represent any assignment or expression

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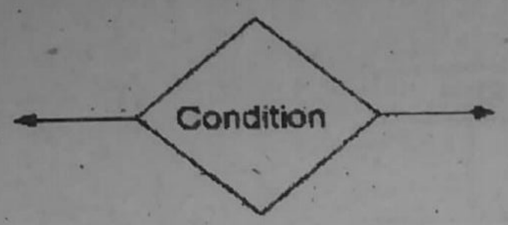
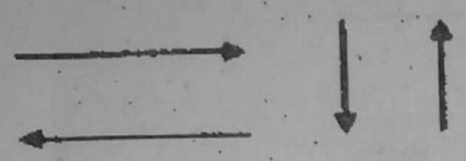
4. Decision



used for any decision making statements.

5. Direction of data flow or flow lines

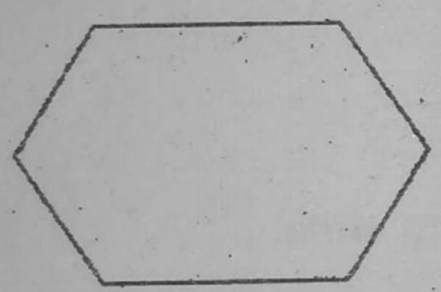


indicates flow of sequence or control.

6. connector

connecting flow lines from different places.

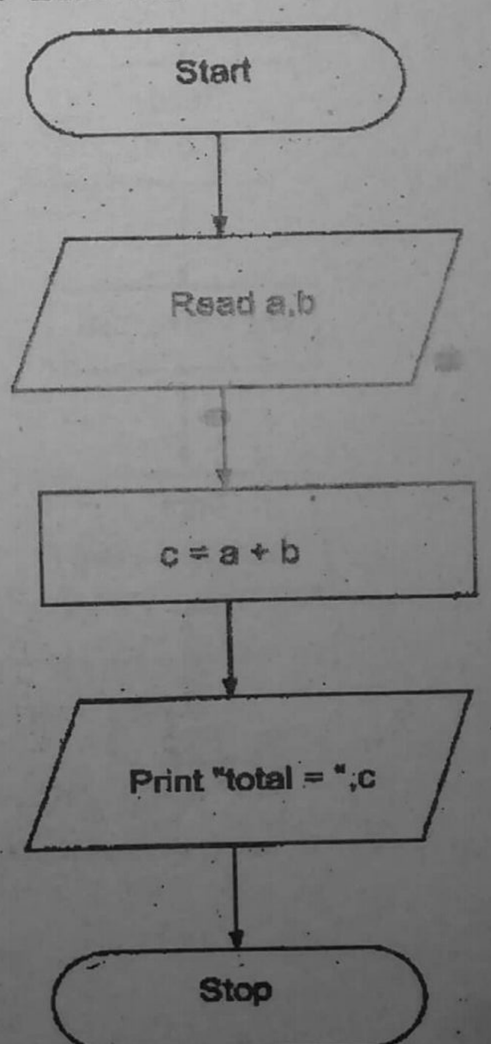
7. loop



used for iteration or looping statement.

2.4 FLOWCHART EXAMPLES :

1. Draw a flowchart to find sum two numbers.



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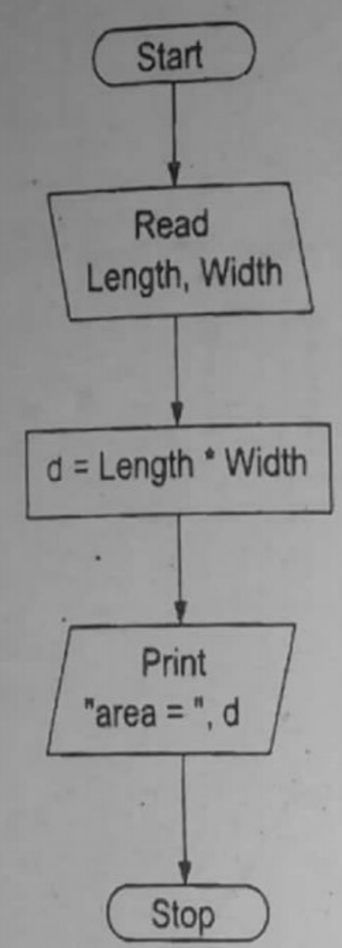
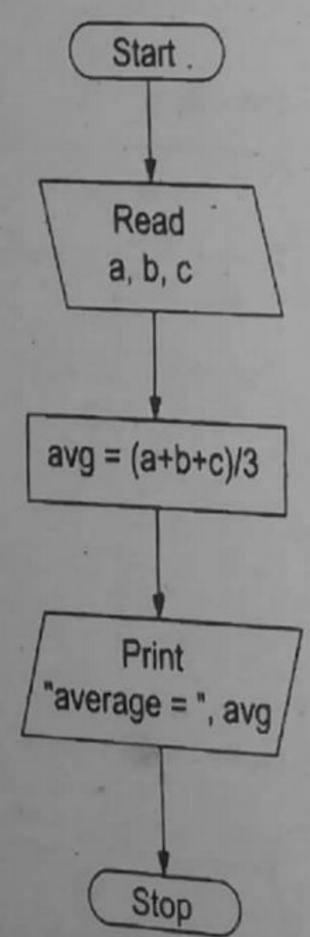
2. **Draw a flow chart to find area of rectangle.**

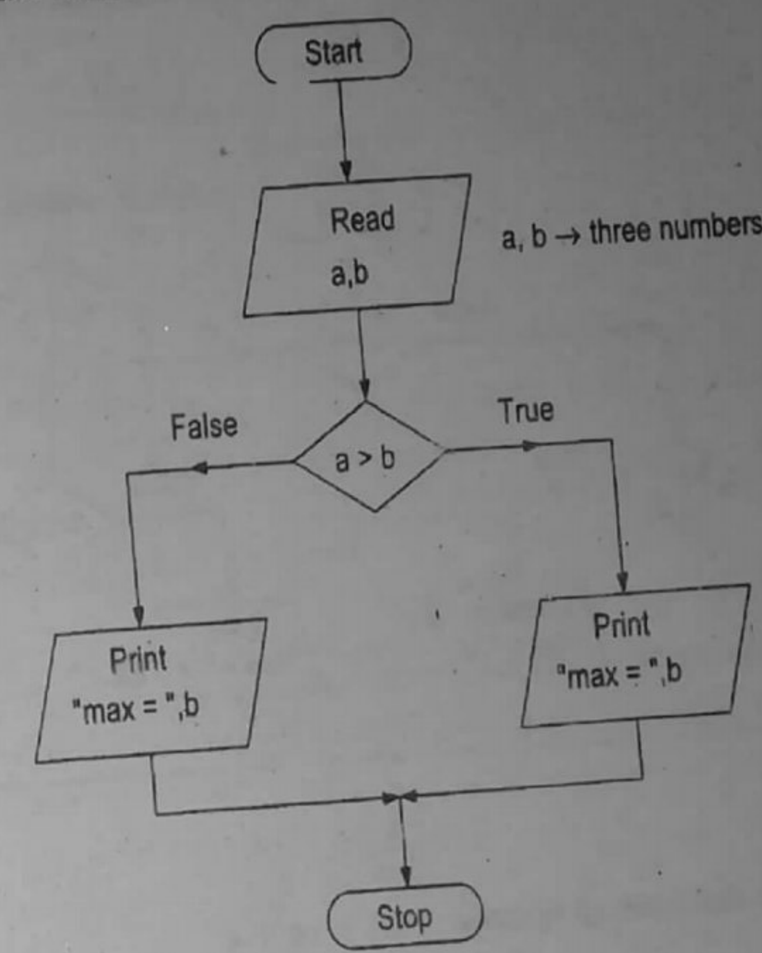


3. **Draw a flowchart to find averge of three subjects marks.**

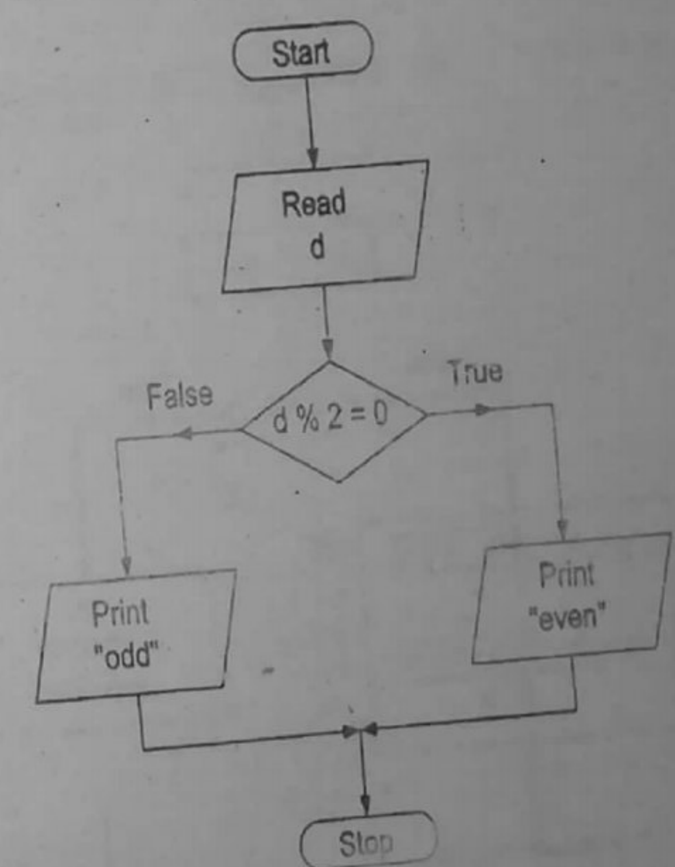


a, b, c → three subject marks

4. **Draw a flowchart to find maximum number from two numbers.**



5. **Draw a flow chart to find whether given number is ood or even.**



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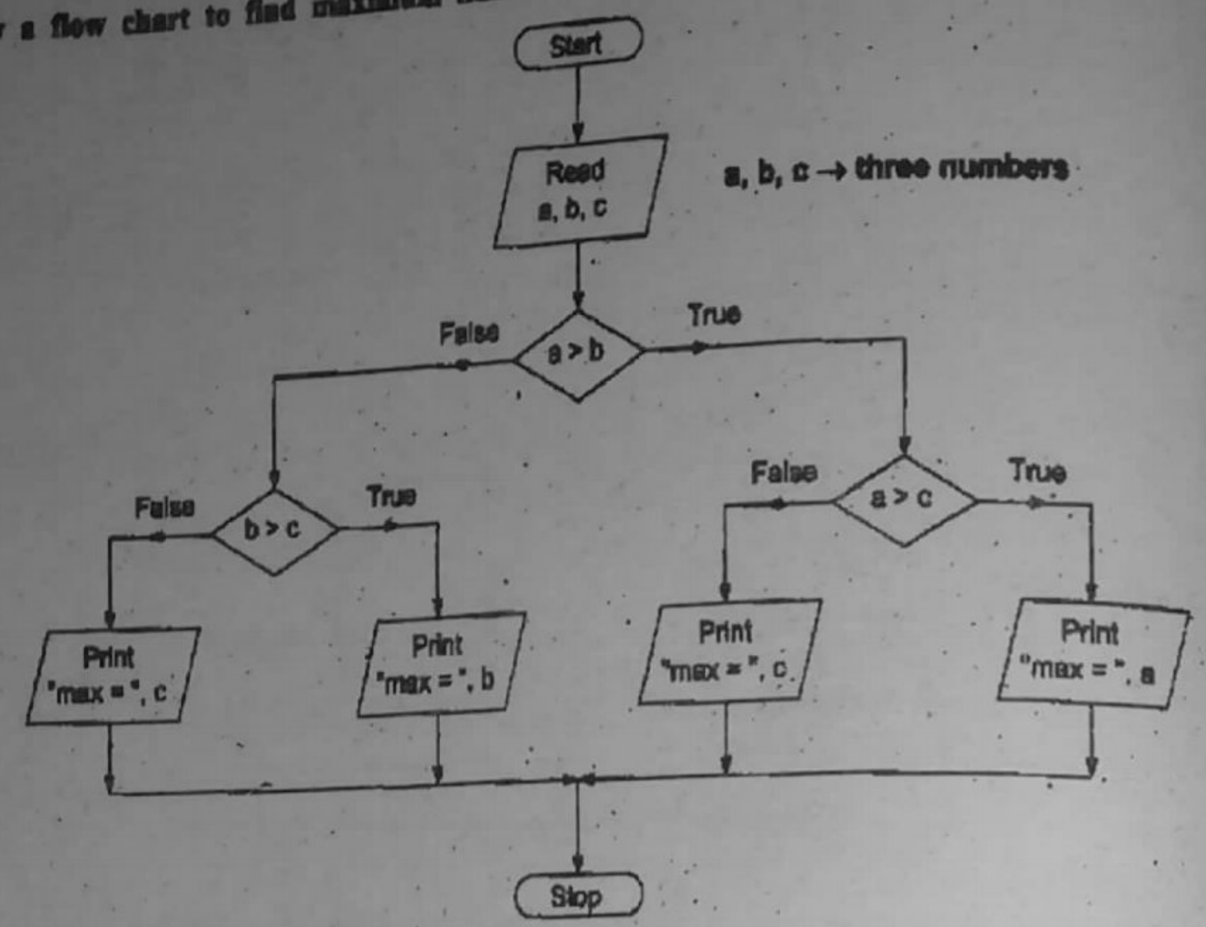
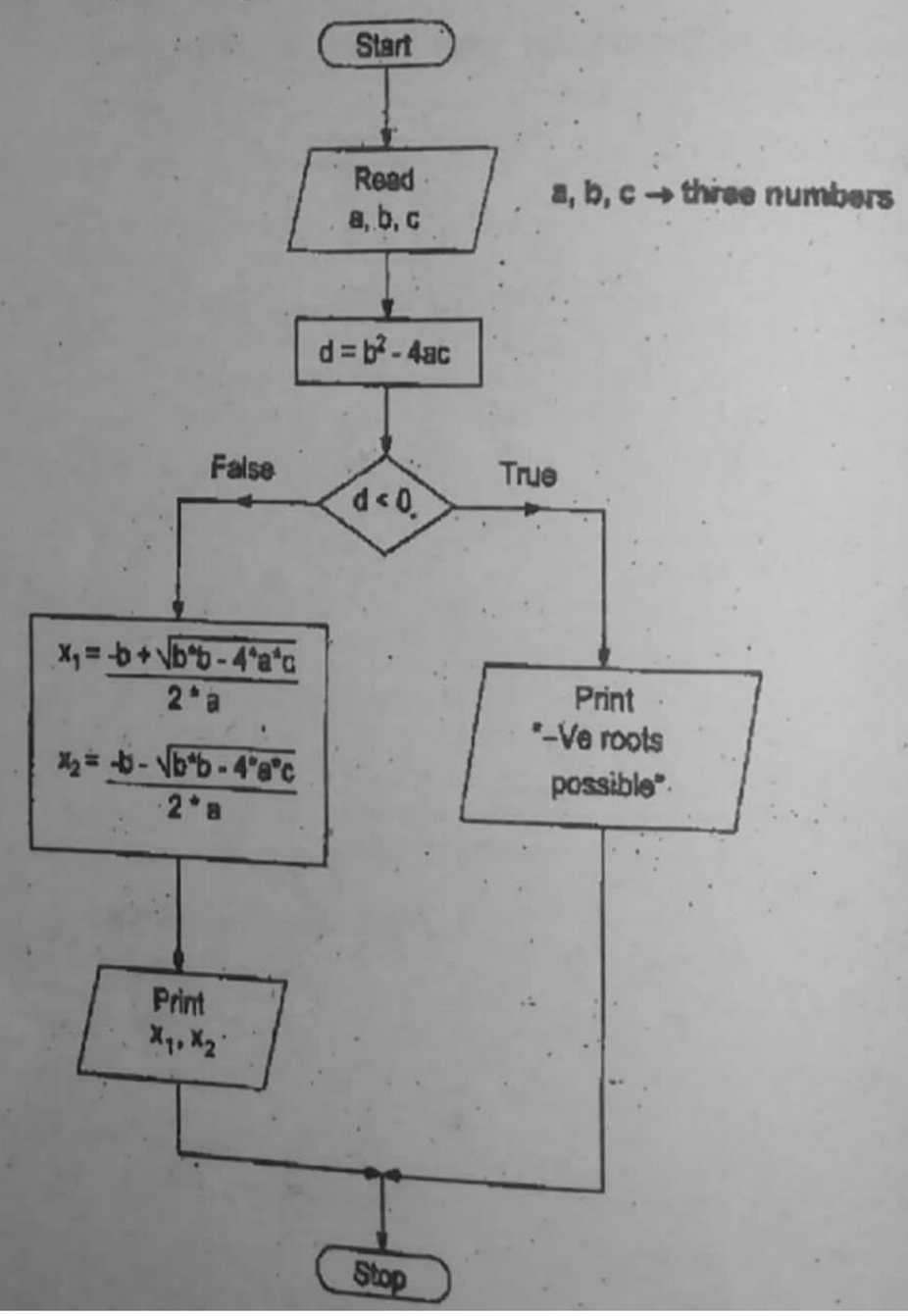
6. **Draw a flow chart to find maximum number from three different numbers**

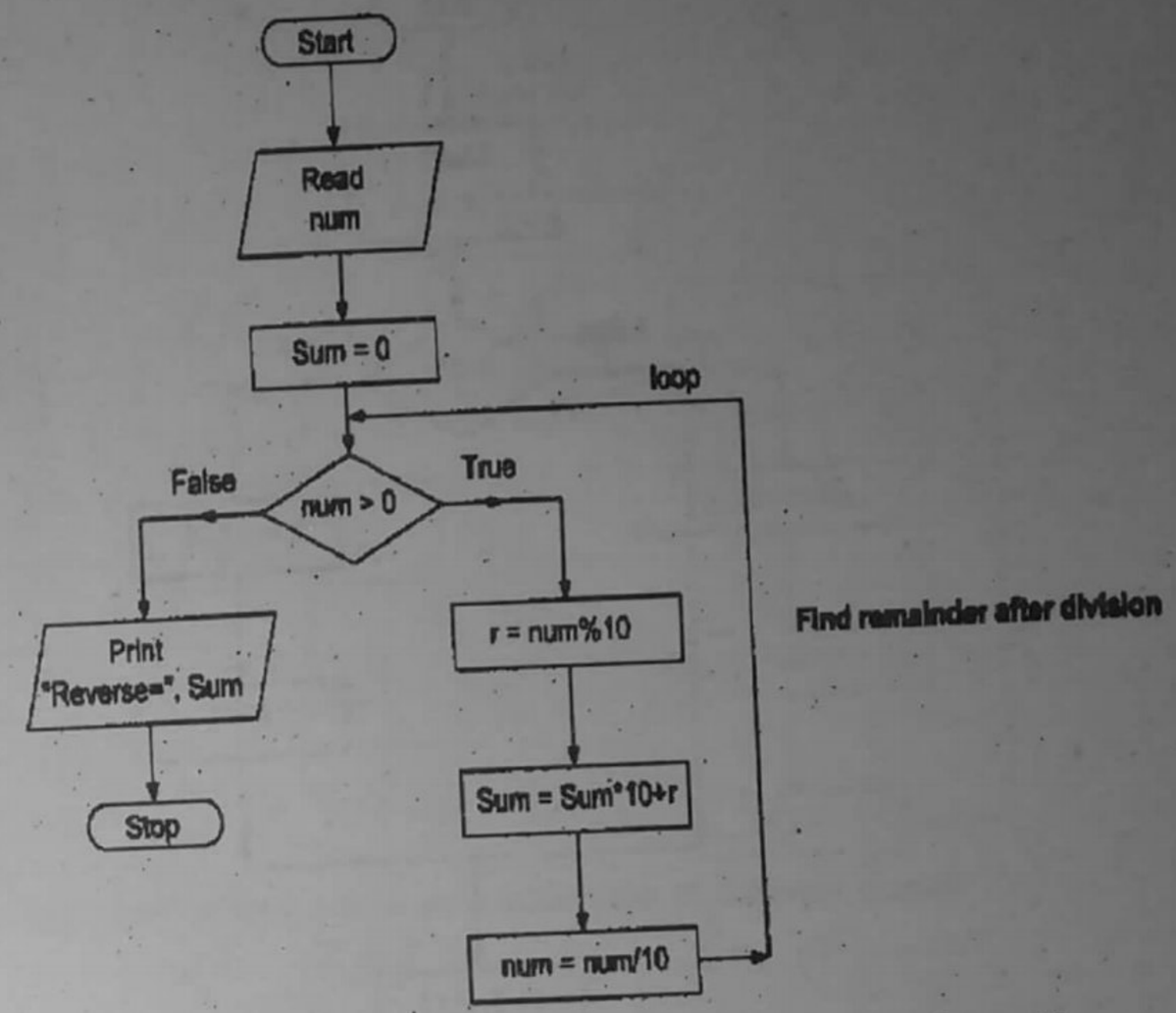


7. **Draw a flow chart to find root of equation : $ax^2 + bx + c$**

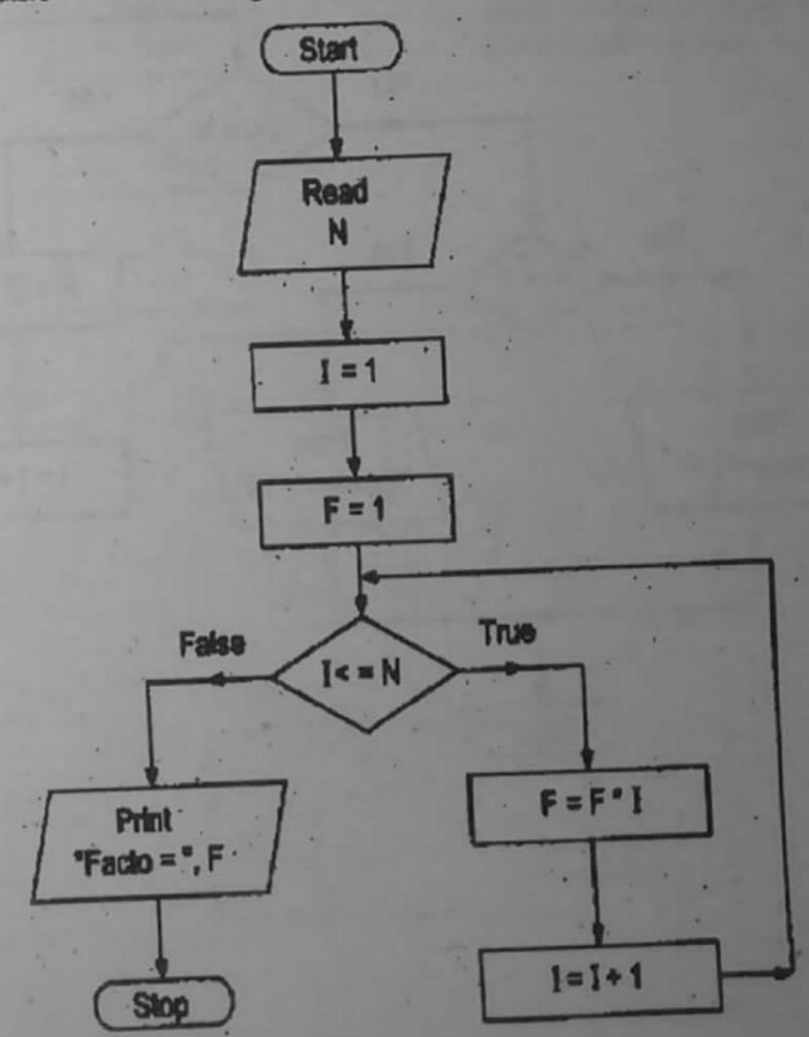


8. **Draw a flow chart to reverse given number.**

e.g. 121 → 321



9. **Draw a flow chart to find factorial of given number : $f = 1 \times 2 \times 3 \times \ldots N$**



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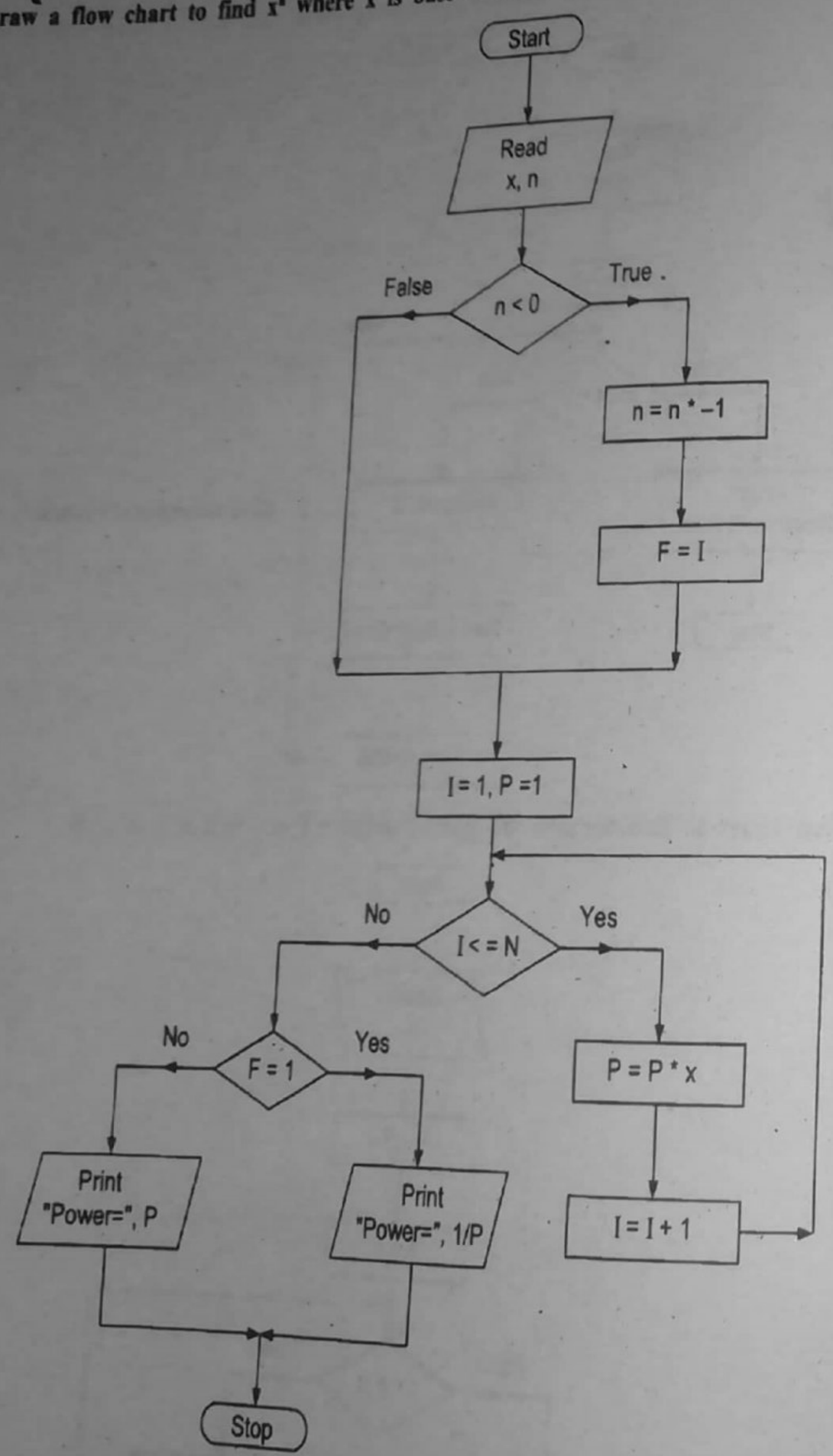
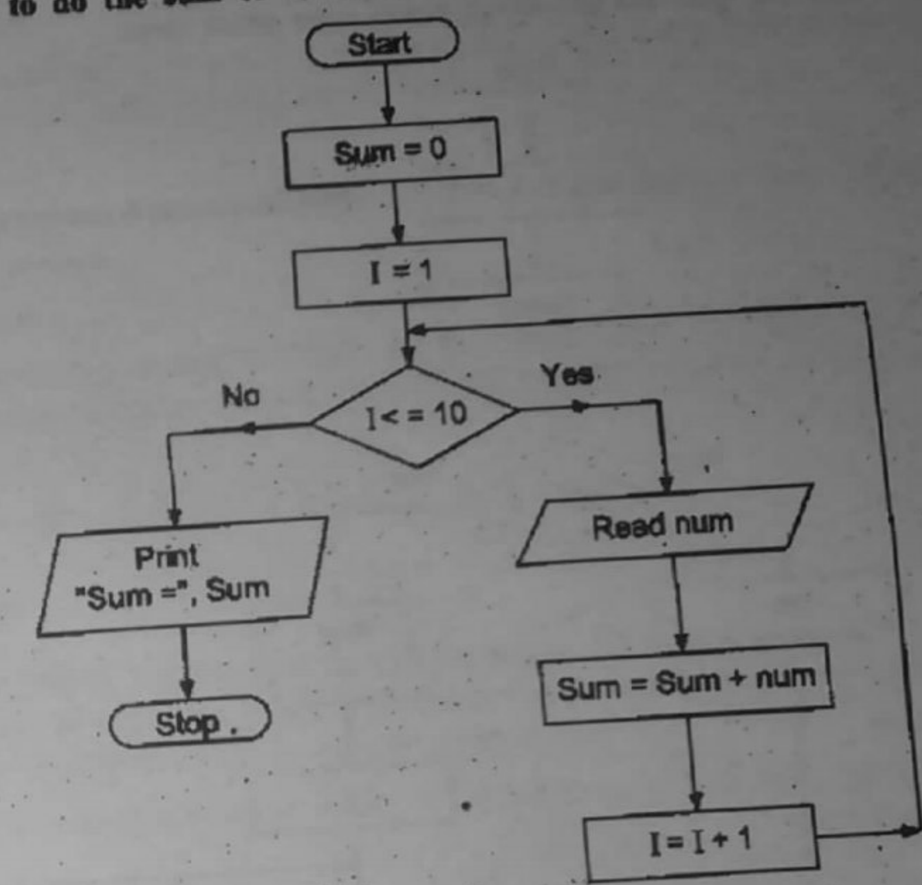
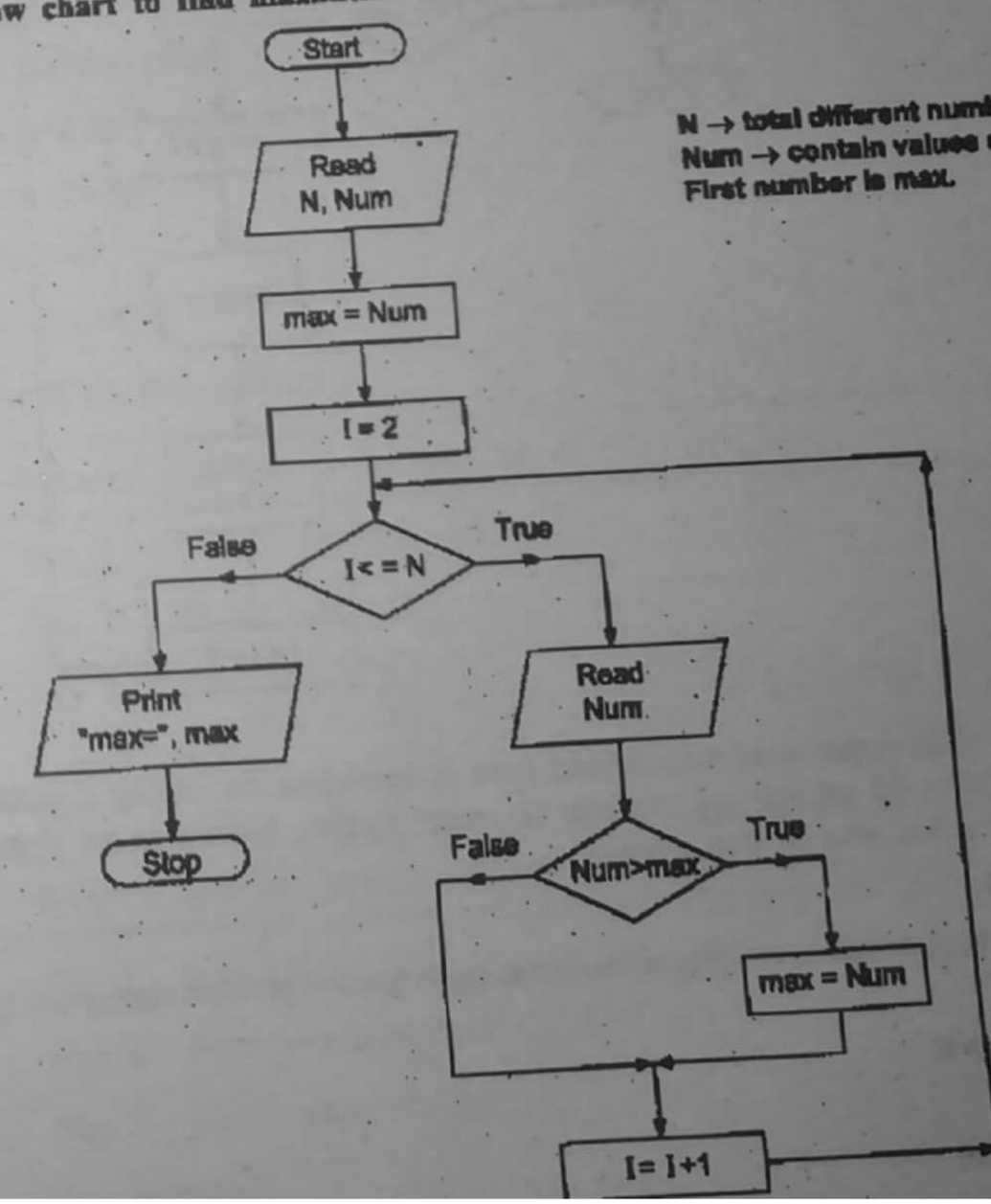
10. Draw a flow chart to find x^n where x is base and n is power.



11. Draw a flow chart to do the sum of 10 elements read from user.



12. Draw a flow chart to find maximum number from N different number.



N → total different numbers
Num → contain values of number
First number is max.

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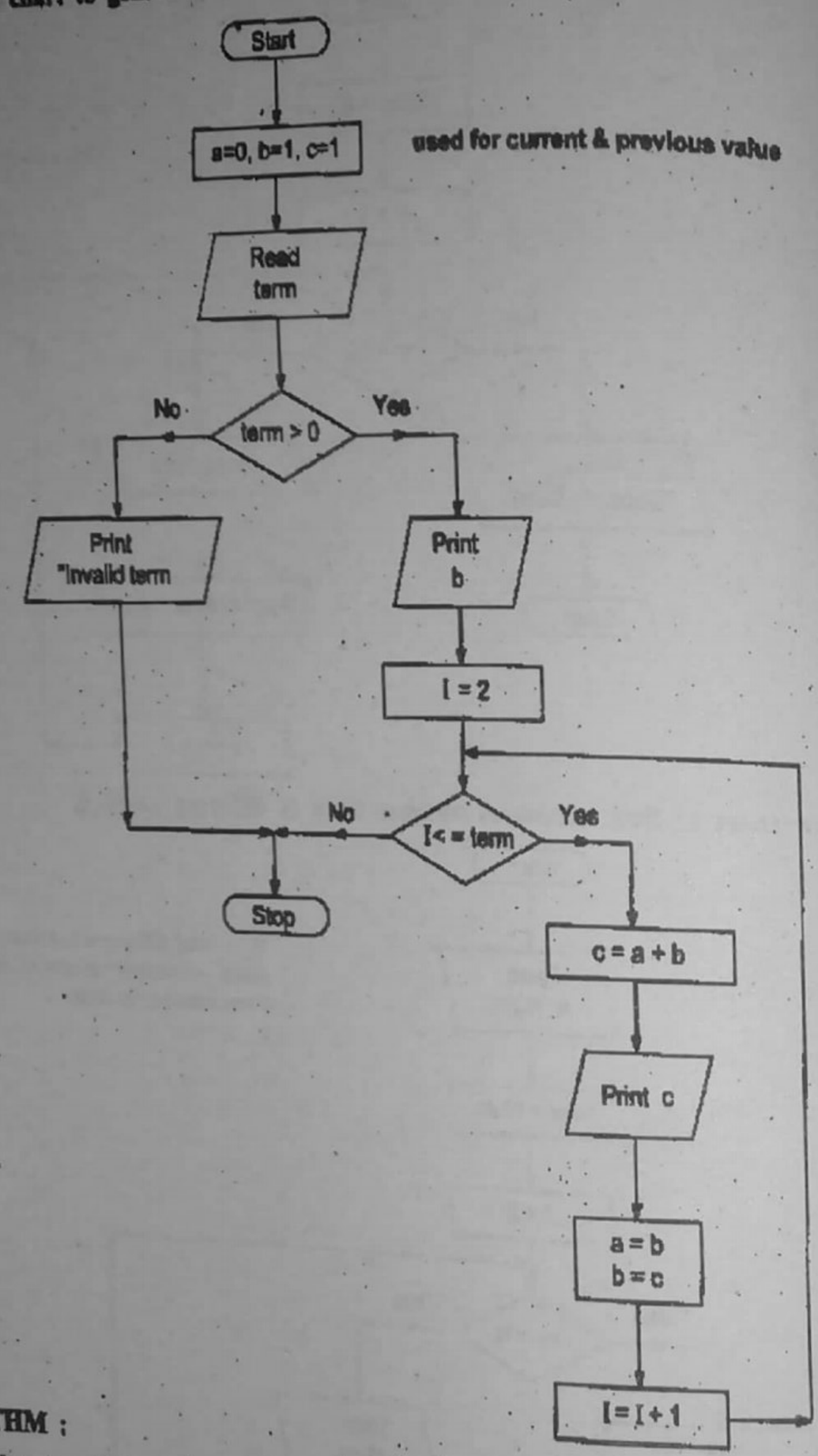
13. Draw a flow chart to generate fibbonacci series upto given term.



2.5 ALGORITHM :

An **algorithm** is a finite sequence of well defined steps or operations for solving a problem in systematic manner. These are rules for solving any problems in proper manner. Instruction are written in the natural language. It is also called step by step solution.

Types of algorithm

There are various types algorithm techniques exists, according to types of problem appropriate types of algorithm used.

1. divide and conquer
2. greedy method
3. branch and bound

1. **Divide and conquer :**

   The divide and conquer technique is used to solve complex problem easily. Complex problems are decomposed into several step, which make problem easy to solve.

2. **Greedy method :**

   This method is used to solve optimization problem. With several possible solution one best solution is selected with help of this method.

3. **Branch and bound :**

   When there are several statement or certain part of logic repeated this type of concept is used. A branch and bound algorithm computes a number(bound) at a node to determine whether the node is promising.

4. **Recursion :**

   When procedure call itself is called recursion.

2.6 PSEUDO CODE :

It is language or part of language used to convert program into easy form. It allows the programmer to write logic of flowchart or algorithm in symbolic form. Hence, pseudo code is a computer instruction without referring to any specific compiler or programming language.

The pseudo code normally consists of phrases of English language to describe the logic steps of a programming module.

Pseudo code can be used for following situation.

1. storage declaration
2. assignment of any value.
3. procedure call
4. input/output
5. constant value

2.7 ALGORITHMS EXAMPLES :

1. Write an algorithm to find out sum of two numbers.

Step 1 : input two numbers : a,b

Step 2 : calculate sum = a+b

Step 3 : Print "total = ",sum

Step 4 : stop

2. Write a algorithm to find out are of square.

Step 1 : input length : len

Step 2 : calculate area=len*len

Step 3 : print " area = ", area

Step 4 : stop

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3. Write an algorithm to find average of three numbers.

Step 1 : input three numbers : a,b,c
Step 2 : calculate sum=a+b+c
Step 3 : avg= sum /3
Step 4 : print "average = ",avg
Step 5 : stop

4. Write an algorithm to find whether given number is positive or negative.

Step 1 : input number : num
Step 2 : check if num < 0 then go to step 5
Step 3 : print "positive "
Step 4 : stop
Step 5 : print "negative "
Step 6 : stop

5. Write an algorithm to find out minimum number from three input numbers.

Step 1 : input three numbers : a,b,c
Step 2 : if a < b then go to next step otherwise (else) go to step 8
Step 3 : if a < c then go to next step else go to step 6
Step 4 : print " minimum = " , a
Step 5 : stop
Step 6 : print " minimum = " , c
Step 7 : stop
Step 8 : if b < c then go to next step else go to step 11
Step 9 : print "minimum = " , b
Step 10 : stop
Step 11 : print " minimum = " , c
Step 12 : stop

6. Write an algorithm to find factorial of given number

Step 1 : input number : num
Step 2 : i=1
Step 3 : f = 1
Step 4 : repeat from step 4 to step 6 until I <= num
Step 5 : f=f *i
Step 6 : i=i+1
Step 7 : print " factorial = ",f
Step 8 : stop

7. Write an algorithm to reverse given number.

Step 1 : input number : num
Step 2 : sum=0
Step 3 : repeat from step 3 to step 6 until num > 0
Step 4 : calculate r = num % 10
Step 5 : calculate sum = sum * 10 + r
Step 6 : calculate num = num / 10
Step 7 : print " reverse number = ",sum
Step 8 : stop

8. Write an algorithm to solve following series 1! + 2! + 3! + ... + n !

Step 1 : input number : num
Step 2 : f=1
Step 3 : sum=0
Step 4 : I =1
Step 5 : repeat from step 5 to step 8 until I <= num
Step 6 : f=f*I
Step 7 : sum=sum + f
Step 8 : I = I +1
Step 9 : print " sum = " << sum
Step 10 : stop

9. Write an algorithm to find whether given number is armstrong or not.

Step 1 : input number : num
Step 2 : sum=0, temp = num // store num to temp
Step 3 : repeat from step 3 to step 6 until num > 0
Step 4 : calculate r = num / 10
Step 5 : calculate sum = sum + r * r * r
Step 6 : calculate num = num % 10
Step 7 : if temp = sum then next step else go t step 9
Step 8 : print temp, "is Armstrong number"
Step 9 : stop
Step 10 : print temp, "is not Armstrong number"
Step 11 : stop

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10. Write an algorithm to find maximum number from n numbers.

Step 1 : input first number : num
Step 2 : max = num
Step 3 : print "how many different numbers"
Step 4 : input n
Step 5 : I = 2
Step 6 : repeat step 6 through step 11 until I <= n
Step 7 : print " input next number "
Step 8 : input num
Step 9 : if num > max then next step else go to step 11
Step 10 : max = num
Step 11 : I = I + 1
Step 12 : print " maximum = " , max
Step 13 : stop

11. Write an algorithm to generate Fibonacci series up to given term.
1 1 2 3 5 8 13 . . . . .

Step 1 : input term
Step 2 : a=0, b=1, c=1 // a,b,c are variable used generate series with previous value
Step 3 : if term > 0 then go to next step else go to step 13
Step 4 : print b
Step 5 : I = 2 // repeat loop up to n times by using I
Step 6 : repeat from step 6 through step 12 until I <= term
Step 7 : print c
Step 8 : c = a+b
Step 9 : a=b
Step 10 : b=c
Step 11 : I = I + 1
Step 12 : stop
Step 13 : print " invalid term " // else part of if
Step 14 : stop

12. Write an algorithm to store sum of 10 different numbers

Step 1 : sum =0
Step 2 : I = 1
Step 3 : repeat from step 3 through step 6 until I <= 10 // 10 times loop
Step 4 : read num
Step 5 : sum = sum + num
Step 6 : I = I +1
Step 7 : print " total = " , sum
Step 8 : stop

13. Write an algorithm to find whether given number is prime or not

Step 1 : read num
Step 2 : I = 2
Step 3 : repeat through step 3 to step 7 until I < num // up to num – 1
Step 4 : if num % I = 0 then go to next step else go to step 7
Step 5 : print num " is not prime "
Step 6 : stop
Step 7 : I = I + 1
Step 8 : print num, " is prime "
Step 9 : stop

14. Write an algorithm to find occurrence of given number from 10 different numbers by using array

Step 1 : dim a(10) // array of ten elements
Step 2 : I = 1
Step 3 : repeat from step 3 to step 6 until I <=10
Step 4 : read a(I)
Step 5 : I = I + 1
Step 6 : read num // num value is to be search from array
Step 7 : count = 0 // count gives occurrence of number
Step 8 : I = 1
Step 9 : repeat from step 9 through step 12 until I < = 10 // search number
Step 10 : if num == a (I) then go to next step else go to step 12
Step 11 : count = count + 1
Step 12 : I = I +1
Step 13 : print num " occurs " count " times "
Step 14 : stop

: MCQs :

1. _____ is a diagrammatic way to represent steps to solve any problem, while _____ is a sequence of instructional steps to be followed to solve any problem.
   (a) Flowchart, Instructions (b) Flowchart, Algorithm
   (c) Workflow, Algorithm (d) None of above
2. Diamond shape symbol is used to represent _____ in flowchart
   (a) Start (b) Stop (c) Input/Output (d) Decision
3. In flowchart, Rectangle shape is used to represent
   (a) Start (b) Process (c) Stop (d) Decision
4. What is algorithm?
   (a) Application code (b) Type of programming language
   (c) Step by step procedure for calculations (d) None of above

: ANSWERS :

1. (b) 2. (d) 3. (b) 4. (c)

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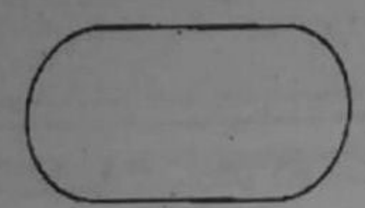
LONG QUESTION ANSWERS

1. What is Algorithm and Flowchart? Explain with some suitable example.

Ans. :

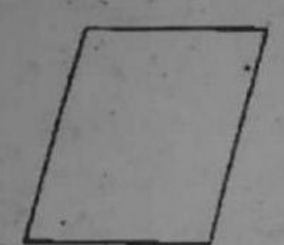
A **Flowchart** is graphical or diagrammatical representation of sequence of any problem to be solved by computer programming language. It is used to prepare first before to write any program. It is also used to correct and debug a program flow after coding part is completed. Through flowchart it is easy to understand the logic and sequence of problem. After drawing flowchart it become to easy write any program. There are various standard symbols available to represent logic of problem which are ...

1. Start and Stop



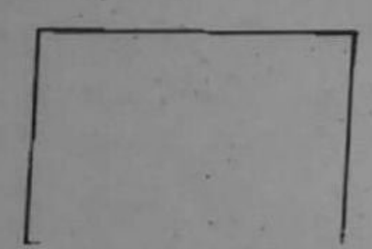
Used to start and stop or end flow chart.

2. Input / Output



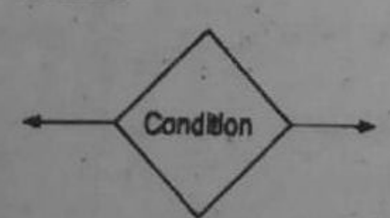
Used for input and output operation

3. Process or expression representation



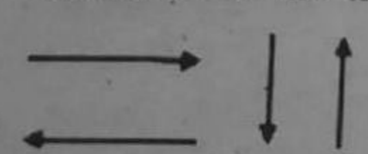
Used to represent any assignment or expression

4. Decision



Used for any decision making statements.

5. Direction of data flow or flow lines

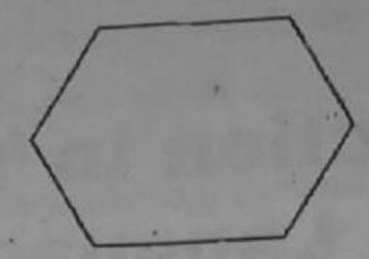


Indicates flow of sequence or data.

6. Connector

Connecting flow lines from different places.

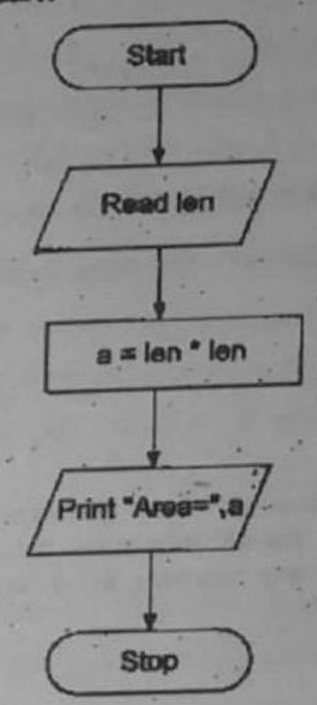
7. Loop



Used for iteration or looping statement.

Example :

1. Draw a flowchart to find area of square.



Algorithm

An **algorithm** is a finite sequence of well defined steps or operations for solving a problem in systematic manner. These are rules for solving any problems in proper manner. Instruction are written in the natural language. It is also called step by step solution.

Types of algorithm

There are various types algorithm techniques exists, according to types of problem appropriate types of algorithm used.

1. Divide and conquer
2. Greedy method
3. Branch and bound
4. Recursion
5. Effectiveness

Example

Write an algorithm to find out area of square.

Step 1 : input length : len

Step 2 : calculate area=len*len

Step 3 : print area= " area = ", area

Step 4 : stop

: SHORT QUESTIONS :

1. What is pseudo code?

⇒ It is a language or part of language used to help programmer to write logic of flowchart or algorithm in symbolic form.

2. What is an algorithm?

⇒ Algorithm is a step by step procedure for solving a given problem.

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Module-3

Introduction to 'C' Language

3.1 INTRODUCTION :

'C' is the language of choice for most of the beginners. 'C' provides almost all the features which programmers require. Before going into the details of 'C' language, we will understand the types of programming languages.

3.2 CLASSIFICATION OF COMPUTER LANGUAGES :

The computer languages can be classified into following 3 different categories.

1. Machine Language
2. Assembly Language
3. High Level Language

Machine Language :

It is the language which is directly understood by the processor. The processor understands only the binary language (language of 0s and 1s). The person who does the programming at machine level is known as Machine langauge programmer. For writing machine level language, the person must know the hardware level details of processor and the memory.

The instruction consists of two parts :

Op code Operand

Op code specifies the name of operation and the operand specifies the data on which the operation is to be performed. The data may be specified directly or through the register or through memory address.

The advantage in writing machine language is that no translator is required because it is written in the language the processor directly understands. The disadvantage is that the program will run on that type of processor only. Also it is very cumbersome to write the machine language program because one has to deal with sequence of 1s and 0s.

Assembly Language :

It is an improvement over Machine language programming. It makes use of **Mnemonics Operation Code** and uses symbolic addresses, so program looks like written using some English language words. It is easy for the programmer to remember the Mnemonics Operation Code rather than sequence of 1s and 0s.

Instructions in assembly language consist of 3 parts.

Label : Mnemonic OpCode Operand

Label specifies the symbolic address given to the instruction. This field is optional and used only if this instruction is required to be referred by other instructions in the program. **Mnemonic OpCode** specifies the name of operation to be performed. **Operand** specifies on what data that operation is to be performed.

The advantage of using assembly language is it is easy for the programmer to remember Mnemonic Opcode, which reduces errors in programming, program is easy to maintain.

The disadvantage is that the program will run only on that processor for which it is developed; the translator is required to convert assembly language into machine language. The translator program which converts assembly language into machine language is known as **assembler**.

High Level Language :

In the machine language and assembly language programming, the programmer has to understand the architecture of the processor on which the program is to be run. High level languages are the languages which enable the programmer to concentrate more on the logic part and not on the architectural details of the processor. This improves the efficiency of the programmer. High level languages use English words and some mathematical symbols. Examples of high level languages are Basic, COBOL, Pascal,FORTRAN,C,C++,Java etc.

The advantages are it is easy to learn and use, the program is machine independent, and efficiency of programmer is improved, easy maintenance of program.

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The disadvantage is that it requires a special converter (known as **compiler**) which will convert high level language into machine language. The programs are less efficient storage wise and time wise in comparison with machine language and assembly language.

For every separate high level language, you require its own separate compiler. Which means C compiler will compile C programs while Java Compiler will compile Java programs. The compiler will generate an error, if the program contains any invalid instruction, which is not recognized by that high level language.

3.3 FEATURES OF 'C' :

Denis Ritchie developed 'C' language. Previous version was known as 'B' language. Important feature of 'C' language is it is **portable**, by portability we mean that the program can be run on any hardware machine. Other features are it is **modular language**, supports **bit-wise operations** and does not provide input-output statements. The bit-wise operations allow the programmer to do the operations on the data bit by bit, which is a feature of machine language. Because of this facility, 'C' is also known as **middle level language.**

The other important feature of 'C' language is that it is **modular**. The large problem is divided into small sub problems (modules). Each module is individually approached as a separate sub problem and solution is found. Then all the modules are put together and the solution of the large problem is derived. Because of the modularity support, 'C' language is also called as **structured programming language.**

3.4 CHARACTER SET :

Every language has its own character set. 'C' language has its own character set. 'C' program basically consists of keywords, identifiers, constants, operators and some special symbols.

The characters that can be used in a 'C' program are **Alphabets** (A-Z and a-z), **Digits** (0-9), **Special Characters** and **White Space Characters**.

Special Characters - ~ ! @ # $ % ^ & * ( ) _ + { } [ ] : ; ' " < > . ? / \ |'

White Space Characters – Space, Tab, Return, New Line, Form feed

3.5 KEYWORDS :

Keywords are words whose meaning is fixed and is known by the compiler, you can not use it for other purpose i.e. we can not change the meaning of keyword. Keywords are also known as reserved words. The keywords must be in second alphabet.

The 'C' language keywords as per ANSI standard.

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

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3.6 IDENTIFIERS :

These are the words which are defined by the programmer in a program. Identifiers can be the symbolic constants, functions, procedures. The name of identifier should be meaningful so that the of the program becomes easy. The rules for naming an identifier are

- The first character must be an alphabet.
- Underscore ('_') is valid letter.
- Reserved words i.e. keywords can not be used as identifiers.
- Identifier names are case sensitive. i.e. name and Name are treated as different identifiers

3.7 STRUCTURE OF A 'C' PROGRAM :

Every 'C' program has to follow specific structure. 'C' program must have at least one function c main(). The main() function has control over the other part of the program. Execution of the progra from the main() function. The 'C' program structure is as shown below:

Documentation
Header files
Constants and Global variables

`main()`
`{`
`Statement(s)`
`}`

User defined functions and procedures with their body

Program :

```
/* Write a program to print the message
Hello ! */
#include <stdio.h>
void main()
{
    printf("Hello !");
}
```

When we run this program, the result will be

Output :

```
Hello !
```

Now, let us relate the above program with the structure of 'C' program. In our program we have not p any documentation regarding the person who developed the program, date on which it was developed, a the purpose of the program. If we want, we can write it as documentation using comments. Comme will be introduced later.

The line `#include <stdio.h>` includes the header file named as stdio.h. This file is necessary to be include in our program whenever we are doing Input-Output operations. In our program, printf () function is fo displaying some data on screen (Output operation), so stdio.h must be included.

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In our program, we have not used any symbolic constants or global variables.

Then, next is the line **void main()** which indicates the main() function. The void keyword indicates it does not return any value to operating system. Within the brackets { and } the body of main() function is written. The symbol { indicates start of main function, while the symbol } indicates the end of the program.

The statement **printf("Hello !");** actually prints the

Hello !

message on the screen. In 'C' all the statements must be terminated by semicolon ';' symbol. That is the reason why there is a semicolon after printf("Hello !").

Following figure shows the Turbo-C IDE with a program

≡ File Edit Search Run Compile Debug Project Options Window Help

```
═══════[■]═══ \GTU\CMAT\HELLO.C═══════════5═[↕]═══
/* Write a program to print the massage
Hello ! */
#include <stdio.h>
void main()
{
printf("Hello !\n");
}
═══10:26═══<■:::::::
```

Output :

```
Hello
World !
```

/* **this program developed by XYZ** */. This line is a comment and will be ignored by compiler. comment is written between /* and */. It improves the readability of the program. Similarly,

/* start of main() */ ,

/* use of '\n' character */ and /* end of main() */ are comments.

In the printf() statement the '\n' character is used. It is called as newline character, it forces the after '\n' to appear on the next line. So Hello and World ! are displayed on separate lines.

3.8 CONSTANTS :

As the name suggests, constant is something whose value does not change throughout the program. 'C' language supports following types of constants:

- Numeric Constants

Numeric constant is a number type of constant. It can be **Integer** constant or **Real** constant. Integer constant can be positive or negative number. In integer constant the special symbols such as space, comma, etc are not allowed.

Following numbers are valid integer constants:

15

–345

0

+7463

While, following numbers are not valid integer constants:

5,000

15 76

$40

'C' language also supports constants in other number system such as octal and hexadecimal. Octal numbers are **preceded by a symbol 0** (zero) and hexadecimal numbers are **preceded by 0x or 0X**.

Real constant is a number having fraction part written after decimal point. It can also be represented in scientific notation also. Following numbers are valid real constants.

0.004

–0.34

645.9

0.56

0.4e–2 scientific notation of 0.004

–3.4e–1 scientific notation of -0.34

- Non-numeric Constants

These are the constants which represent other than number. They are of two types. **Character constants** and **String** constants.

Character constants are single character and are enclosed in single quotes. Characters are represented in computer memory using a coding scheme known as ASCII code. Every character has its associated ASCII code.

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So, valid character constants are: 'B' 'a' '?' '5' '+'

Back slash constants are the special type of character constants which actually consists of two characters. These are known as **escape sequences.** Escape sequences start with backslash '\' character. These escape sequences have their effect at execution time of program.

Escape Sequences and their meaning

Escape Sequence	Meaning
'\0'	End of String – NULL
'\n'	End of line – take the control to next line
'\r'	Carriage return–take the control to next paragraph
'\f'	Form feed - take the control to next logical page
'\t'	Horizontal tab
'\b'	Back Space
'\\'	Prints backslash character \
'\a'	Alert – provide audible alert
'\"'	Double quote – prints double quote

String constant is a sequence of characters which are enclosed in double quotes. Valid character constants are:

"Vansh"

"Computer"

"–345"

"B"

Here, "–345" and –345 are different. The same applies to "B" and 'B'.

3.9 VARIABLES :

In the program, the other type of identifier called variable which is used whose value changes as the program statements are executed. So, variables are the identifiers whose value changes as opposite to constants. As variable is an identifier, all the rules for naming an identifier applies to variables also.

So, following are **invalid** variables

Name	Remark
1abc	The first character is number
int	**int** is a reserve word, it can not be used to declare identifier
double	**double** is a reserve word, it can not be used to declare identifier
sum qty	space not allowed

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3.10 DATA TYPES :

The 'C' language supports 4 fundamental data types. These data types are as below

Type	Purpose	Size (Bytes)	Range of values
char	for storing characters and strings	1 Byte	–128 to +127
int	For storing integers	2 Bytes	–32768 to +32767
float	For storing real numbers	4 Bytes	3.4e-38 to 3.4e+38
double	For storing double precision floating numbers	8 Bytes	1.7e-308 to 1.7e+308

In addition to fundamental 4 types of data, 'C' language supports different qualifiers such as **signed, unsigned, short** and **long**. These qualifiers can be put before the fundamental data types to change the range of values supported. These data types with their size and range are as below.

Type	Size (Bytes)	Range of values
unsigned char	1 Byte	0 to 255
unsigned int	2 Bytes	0 to 65535
short int	2 Bytes	–32768 to +32767
unsigned short int	2 Bytes	0 to 65535
long int	4 Bytes	–2147483948 to +2147483647
unsigned long int	8 Bytes	0 to 4294967295
long double	10 Bytes	3.4 e–4932 to 1.1e+4932

As shown in above two tables, when you want to store only positive numbers, then only unsigned qualifier should be used. The long qualifier uses more bytes, so we can store very large number. So, whether to use qualifier or not that depends on your requirement.

3.11 VARIABLE DECLARATION :

In 'C' , the variable must be declared before using it in program. The syntax for variable declaration is:

```
datatype var1,var2,...,varn;
```

Here, datatype is one of the 4 fundamental data types with or without qualifier. After the data type we have to write the name of variables separated by comma. Here, var1,var2 upto varn are the name of variables. It is not necessary to declare all variables of same type in one line.

Following are valid declaration of variables.

```
int sum, count;
float weight, average;
double rho;
char c;
```

3.12 ASSIGNING VALUES TO VARIABLES :

Once the variable is declared, it can be assigned a value in the program. Assignment operator = is used to assign a value to a variable.

Syntax :

```
variablename = value;
```

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Example :

```
weight = 55.5;
sum =  0;
```

We can also assign a value to a variable at the time of declaration using following syntax :

```
datatype variablename = value;
```

Example :

```
int sum =0;
int length, count=0;
```

3.13 SYMBOLIC CONSTANTS :

When a constant is used at many places in a program, Due to some reason if the value of that constant needs to be changed, then we need to change at every statement where that constant occurs in the program – so modification of program becomes difficult. If the same program is to be understood by other person then understanding becomes difficult. The symbolic constant helps us in solving these problems. Here, the constant is given a symbolic name and instead of constant value, symbolic name is used in the program.

Symbolic constant is defined as below :

```
#define symbolic_name value
```

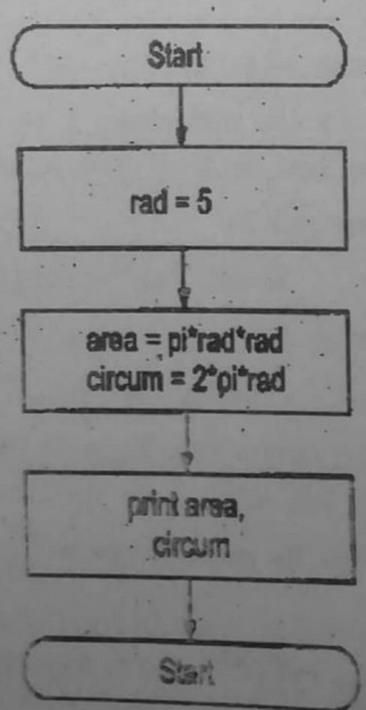
Example :

```
#define FLAG 1
#define PI 3.1415
```

Here, FLAG and PI are symbolic constants. For better readability, it is advisable to use uppercase characters in the naming of symbolic constants. See that there is **no semicolon** ';' at the end.

Following program with flowchart explains the concept of declaration and assigning the values to variables and using symbolic constants.

Flowchart :



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Program :

```
/* Program illustarting use of declartion, assignment of value to variables. Also explains how to use symbolic
constants.
Program to calculate area and circumference of a circle */
#include <stdio.h>
#include <conio.h>
#define PI 3.1415      /* no semicolon here */
main()
{
    float rad = 5;  /* declaration and assignment */
    float area, circum; /* declaration of variable */
    clrscr();
    area = PI * rad *rad;
    circum = 2 * PI *rad;
    printf("Area of circle = %f\n",area);
    printf("Circumference of circle =%f\n",circum);
}
```

Output :

```
Area of circle = 78.537498
Circumference of circle =31.415001
```

3.14 ENUMERATED DATA TYPE :

It is a user defined data type. As a programmer we can define our own data types. We can define more than one integer symbolic constants.

Syntax :

```
enum identifier(value1,value2,...,valuen);
```

Example :

```
enum day(sun,mon,tue,wed,thu,fri,sat);
```

Here, enum is a keyword, day is a data type defined & the possible values are as specified in brackets. So, any variable declared of day type can have values which we have specified within brackets.

We can declare variable of enum type as

```
enum day today;
```

We can assign value to variable as

```
today = sun;
```

The compiler automatically assigns integer digits beginning with 0 to all the enumerated constants. For the above example, sun=0, mon=1,... and sat=6.

We can also create the enum type for name of months.

Example:

```
enu      mmonth(jan=1,feb,mar,apr,may,jun,jul,aug,sep,oct,nov,dec)
```

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Here, jan is initialized with value =1, so compiler will assign feb=2,mar =3 and at last dec=12. Now, we can declare variables of month type and use them in the program.

3.15 TURBO-C IDE HOT KEYS :

Following table shows important hot keys in Turbo-C IDE. Remembering the hot keys will help in working efficiently while writing, compiling, debugging and running the program.

Hot Key	Meaning
F1	Activates on-line help
F2	Save the current file
F3	Load a file
F4	Execute program until cursor is reached
F5	Zoom window
F6	Switch between windows
F7	Trace into function call
F8	Trace, but skip function call
F9	Compile and link a program
F10	Toggle between editor and main menu.
ALT-F3	Pick a file to load
ALT-F5	Go to user screen
ALT-F9	Compile file and create object file
ALT-C	Activate compile menu
ALT-D	Activate debug menu
ALT-E	Activate editor
ALT-F	Activate File menu
ALT-P	Activate project menu
ALT-R	Activate run menu
ALT-X	Quit Turbo-C IDE
CTRL-F1	Context sensitive help
CTRL-F7	Set a watch expression
CTRL-F8	Set or clear a breakpoint
CTRL-F9	Compile and execute the program

3.16 DIFFERENT FILES IN A 'C' PROGRAMMING ENVIRONMENT :

There are mainly four types of files which a student should know about. They are: source code file, header file, object file and executable file.

Source code file :

It contains the source code of the program. Its extension is '.c'. Normally it contains main () function and may include other header files.

Header file :

These are the files having extension '.h'. It contains definitions of built-in functions. When header file is included, related definitions are automatically available in the program.

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Object file :

When we compile a program using a compiler, it generates a compact binary code in a file. The obj file has extension '.obj'.

Executable file :

The linker program generates the executable file by linking various object files and creates one executab file. It has an extension '.exe'.

3.16.1 Compilation and execution of a program :

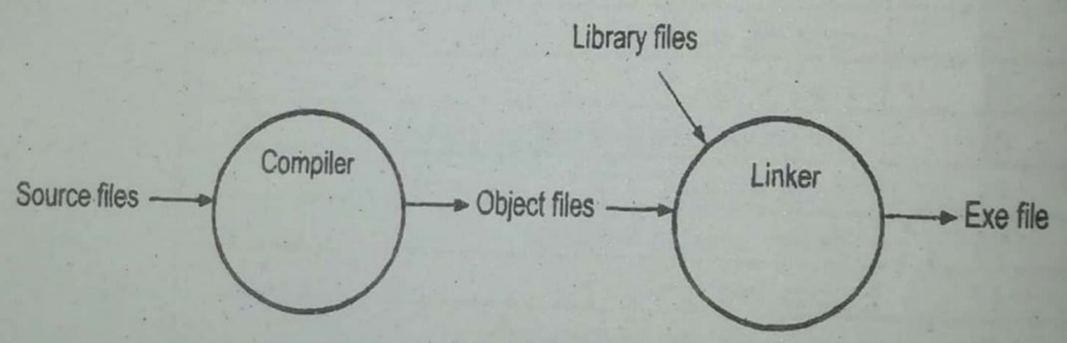

Fig 3.1

As shown in figure 3.1, Source file (.c) file is compiled by compiler and object file is created (.obj) an it is linked by linker with other .obj library files and an executable file is created which can be executed

3.17 TYPE CONVERSION :

Whenever an expression involves two different types of operands, 'C' language applies the type conversio rules to evaluate an expression. At a time only one operator under consideration is taken. If the operand

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are of different type, then the operand with a lower type is upgraded to the higher type and then the operation is performed.

Program :

```
/* Program demonstrating type conversion */
#include <stdio.h>
#include <conio.h>
main()
{
    int a,b;
    float c;
    double d;
    a=5;
    c= 5.5;
    d = 4.0;
    clrscr();
    b = a *c +d /10;
    printf("value of b = %d\n",b);
}
```

Output :

```
value of b = 27
```

Explanation :

In the statement b = a *c +d /10,

a*c will be done first, here a will be upgraded to float because other operand c is float.

So, a*c will evaluate to 27.5. Then, d/10 will be evaluated, 10 will be converted into 10.0 (double) because d is double. So, d/10 will evaluate to 0.4. Then 27.5 + 0.4 evaluates to 27.9. This value is assigned to variable b, which is integer, so truncated value of 27.9 will be the value of b i.e 27 will be assigned to b.

In the case of assignment,

- If float is assigned to integer, then fractional part is truncated as shown in above program.
- If double is assigned to float, then rounding takes place.
- If long int is assigned to integer, then additional bits are dropped, recall that long int requires 4 bytes while int requires only 2 bytes.

3.18 TYPE CASTING :

When user needs the type conversion explicitly, then type casting is used. Remember that type conversion is automatic while type casting is explicitly specified by the programmer in the program.

The type casting can be specified in following form

```
(typename) expression;
```

Here, typename is the name of data type we want to convert the expression to. The converted value is used during evaluation of expression only, it does not change the basic data type of operand(s) of an expression.

For example, float(21) converts 21 integer to float 21.0

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Program :

```
/* Program demonstrating type casting */
#include <stdio.h>
#include <conio.h>
main()
{
    int sum =47;
    int n = 10;
    float avg;
    clrscr();
    avg = sum/n;            /*avg without type cast */
    printf("avg=sum/n       = %f\n",avg);
    avg = (float)sum/n; /*avg with type cast on sum */
    printf("avg=(float)sum/n    = %f\n", avg);
    avg = (float)(sum/n);
                /*avg with type cast on (sum/n) */
    printf("avg=(float)(sum/n)  = %f\n", avg);
}
```

Output :

```
avg=sum/n              = 4.000000
avg=(float)sum/n       = 4.700000
avg=(float)(sum/n)     = 4.000000
```

Explanation :

In the first line of output, integer arithmetic takes place, while in second sum which is 47 is converted in 47.0, so automatically i.e type conversion takes place and 10 becomes 10.0. So, floating-point arithmetic takes place. While in the last line of output, float type casting takes place on sum/n which is 4, converted in float becomes 4.0.

3.19 HEADER FILES :

The files included at the beginning of 'C' program and having an extension .h are called as header files. The content of these files go at the head of the program, in which the header file is included. In 'C' language the prototypes of all the library functions are categorized according to their function in header files. For example, stdio.h header file contains all the library functions for standard Input- Output functionality, that is why the name stdio.h where,

std stands for standard, **i** stands for Input and **o** stands for Output.

Same way, math.h header file contains prototypes of all mathematical library functions.

For example, **sqrt()** function for finding the square root of a number, **pow()** function for finding power of a number.

Following is the list of mostly used header files

- stdio.h contains standard input-output functions.
- math.h contains mathematical functions.
- conio.h contains console input-output functions.

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- string.h contains string processing functions.
- ctype.h contains character type checking functions.

The advantage of using the header files is that we do not have to write the code again and again in each program. Whatever library functions we are using, we have to just include the name of the header file in which the prototype of the function is defined. If we forget to include the header file in the program, and try to use the library function defined in it, then compiler will generate an error message. Detail of header files can be found in the reference manual.

3.20 PREPROCESSOR DIRECTIVES :

Preprocessor is a program that processes the source program before the control is given to the compiler. Preprocessor understands some commands known as preprocessor directives. The directive begins with symbol #. There are many directives which the preprocessor understands. We have already used the directives **include** and **define**.

For example,

```
#include <stdio.h>
# define PI 3.1415
```

Include directive includes the file mentioned after it, while define directive defines a symbolic constant.

Following program uses symbolic constants.

Program :

```
/* Write a program that demonstrates symbolic constants */
#include <stdio.h>
#include <conio.h>
#define cube(x) (x*x*x)
void main()
{
    int ans,a;
    clrscr();
    a=3;
    ans = cube(a);
    printf("Answer = %d\n",ans);
}
```

Output :

```
Answer = 27
```

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: MCQs :

1. The translator program which converts assembly language into machine language is known as
   (a) Compiler (b) Assembler (c) Interpreter
2. The translator program which converts high level language into machine language is known as
   (a) Compiler (b) Assembler (c) Loader
3. Which is not the feature of 'C' language?
   (a) Portable (b) Modular (c) Structured (d) None of
4. Which one is not a keyword of ANSI 'C' ?
   (a) goto (b) int (c) static (d) dynamic
5. Which one is valid constant in 'C'?
   (a) 2,000 (b) $40 (c) 15 76 (d) None of
6. Which escape sequence will provide horizontal tab ?
   (a) '\0' (b) '\t' (c) '\n' (d) None of
7. Which one is valid variable?
   (a) sum (b) temp (c) rate_of_int (d) All of above
8. Which qualifier should be used when we want to store only positive numbers ?
   (a) signed (b) unsigned (c) short (d) None of
9. Which one is correct definition to define symbolic constant FLAG with value 1 ?
   (a) #define FLAG =1 (b) #define FLAG =1; (c) #define FLAG 1 (d) None of
10. The file having extension .h is called as
    (a) Source file (b) Header file (c) Object file (d) Executable
11. C is a _____ language.
    (a) High level (b) Middle level (c) Machine level (d) Low level
12. Which of the following is a correct statement
    (a) Variable name must start with underscore
    (b) Variable name must have digit
    (c) Variable name must have white space character
    (d) Keyword cannot be a variable name.
13. A declaration float a, b; occupies _____ of memory ?
    (a) 1 bytes (b) 4bytes (c) 8 bytes (d) 16 bytes
14. In C language a variable can not start with:
    (a) Special character except underscore (b) Number
    (c) Both a & b (d) Alphabet
15. Macro is used to
    (a) save memory (b) fast execution (c) Both a and b (d) None of

: ANSWERS :

1. (b)	2. (a)	3. (d)	4. (d)	5. (d)	6. (b)	7. (d)
8. (b)	9. (c)	10. (b)	11. (b)	12. (d)	13. (c)	14. (c)
15. (c)						

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LONG QUESTION/ANSWERS

1. **What do you mean by constants in C language? Explain types of constants in detail.**

Ans :

Constant is something whose value does not change throughout the program. C language supports following types of constants.

- Numeric Constants
  - ⇒ Integer constant examples
    - → 15
    - → -345
  - ⇒ Real constant examples
    - → 0.004
    - → -0.45
    - → 5453.4
- Non-numeric Constants
  - ⇒ Character constants are single character and enclosed in single quotes. Examples
    - → 'B'
    - → 'a'
    - → '5'
  - ⇒ String constant is a sequence of characters which are enclosed in double quotes. Examples
    - → "Computer"
    - → "Programming"
    - → "123"

: SHORT QUESTIONS :

1. **What are keywords?**

⇒ Keywords are reserved words in a programming language. Meaning of keywords is fixed and can not be changed by the programmer.

2. **Why comments are used in a program?**

⇒ Comments are used in a program to improve readability of a program. The comment can be written between /* and */.

3. **What are qualifiers in 'C'?**

⇒ Qualifiers are words which are written before basic data types in 'C' to change the range of values supported by basic data types. Qualifiers in 'C' are : signed, unsigned, short and long.

4. **'C' is which type of language?**

⇒ 'C' is middle level language; because it has assembly level as well as high level language features.

5. **What is the extension of 'C' program?**

⇒ Extension of 'C' program is .c

6. **What are enumerations?**

⇒ They are a list of named integer-valued constants.

Example: enum color {black, orange, yellow, green, blue, violet};

The enum actually declares a type, and therefore can be type checked.

7. **Is it possible to have more than one main() function in a C program ?**

⇒ No, The function main() can appear only once. The program execution starts from main function.

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Module-4

Operato

4.1 INTRODUCTION :

Operators help in doing various operations. 'C' language supports rich set of operators. The operators be divided into different categories as shown below.

- Arithmetic operators
- Logical operators
- Increment and Decrement operators
- Bitwise operators
- Relational operators
- Assignment operators
- Conditional operators
- Other special operators

The operators are used inside expressions. Expression is a formula having one or more operands and m have zero or more operands. The operand can be a variable, constant or a name of a function. For examp following is an expression involving two operands a and b with '+' operator.

```
a + b
```

4.2 ARITHMETIC OPERATORS :

Arithmetic operators are used to perform arithmetic operations. 'C' language supports following arithm operators.

Operator name	Meaning
+	Add
–	Subtract
*	Multiply
/	Divide
%	Modulo division (Remainder after division)

The 'C' language does not provide the operator for exponentiation. + and – operators can be used as unar operator also. Except % operator all arithmetic operators can be used with any type of numeric operand while % operator can only be used with integer data type only.

Following program will clarify how arithmetic operators behave with different data type, particularly the us of / and % operator.

Program :

```
/* Program illustrating use of arithmetic operators. The numbers x and y are initialized in the program
itself with x = 25 and y =4 */
#include <stdio.h>
main()
{
    int x=25;
    int y=4;
    printf("%d + %d = %d\n",x,y,x+y);
    printf("%d - %d = %d\n",x,y,x-y);
    printf("%d * %d = %d\n",x,y,x*y);
    printf("%d / %d = %d\n",x,y,x/y);
    printf("%d %% %d = %d\n",x,y,x%y);
```

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Output :

```
25 + 4 = 29
25 - 4 = 21
25 * 4 = 100
25 / 4 = 6
25 % 4 = 1
```

Explanation : First three operations are obvious. The division operation gives the answer 6 because, the variables x and y are integer variables, when we use / with integer operands the result will be integer number. While, % operator produces the remainder after division of 25 by 4.

Following program explains how to get data from user using scanf() function.

Program :

```
/* Program illustarting use of arithmetic operators. This program uses scanf() function to get the numbers
from keyboard */
#include <stdio.h>
main()
{
    int x,y;
    printf("Enter the values of x and y\n");
    scanf("%d%d",&x,&y);
    printf("%d + %d = %d\n",x,y,x+y);
    printf("%d - %d = %d\n",x,y,x-y);
    printf("%d * %d = %d\n",x,y,x*y);
    printf("%d / %d = %d\n",x,y,x/y);
    printf("%d %% %d = %d\n",x,y,x%y);
}
```

Output :

```
Enter the values of x and y
-25 3
-25 + 3 = -22
-25 - 3 = -28
-25 * 3 = -75
-25 / 3 = -8
-25 % 3 = -1
```

Look at the last line of output. Run the program again and try giving positive value of x and negative value for y and check the output.

Following program explains floating-point arithmetic.

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Program :

```
/* Write a program to convert Fahrenheit temperature to centigrade.
This program explains floating-point arithmetic. The formula is c = 5/9*(f-32).
In the program, if we write the formula using 5/9 then, it will result into 0.
Because in integer arithmetic 5/9 =0
To get the correct answer we should write the formula as c= 5*(f-32)/9 or
c= 5.0/9 * (f-32)  or c =5.0/9.0*(f-32)  so that integer gets upgraded to real. */
#include <stdio.h>
#include <conio.h>
main()
{
    float fahr,cent;
    clrscr();
    printf("Give the value of temperature in Fahrenheit\n");
    scanf("%f",&fahr);
    cent = 5*(fahr-32)/9;
    printf("Fahrenheit temperature = %f\n",fahr);
    printf("Centigrade temperature = %f\n",cent);
}
```

Output :

```
Give the value of temperature in fahrenhit
    100
Fahrenhit temperature = 100.000000
Centigrade temperature = 37.777779
```

Program :

```
/* Write a program to find sum and average of 4 integer numbers */
#include <stdio.h>
#include <conio.h>
main()
{
    int n1,n2,n3,n4;
    int sum =0;
    float avg=0;
    clrscr();
    printf("Give four integer numbers\n");
    scanf("%d%d%d%d",&n1,&n2,&n3,&n4);
    sum = n1+n2+n3+n4;
    avg = sum/4.0; /* See 4.0 is used and not 4. We can not wr
    avg=sum/4 because sum and 4 are integers. So answer will
    truncated, which will be wrong */
```

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```
    printf("Sum of %d %d %d %d =%d\n",n1,n2,n3,n4,sum);
    printf("Average of %d %d %d %d =%f\n",n1,n2,n3,n4,avg);
}
```

Output :

```
Give four integer numbers
1 2 3 4
Sum of 1 2 3 4 = 10
Average of 1 2 3 4 = 2.500000
```

The precedence of arithmetic operators is

* / % first priority

\+ -second priority

If in an expression, the operators having same priority occur, then the evaluation is from left to right. Sub expressions written in brackets are evaluated first.

4.3 RELATIONAL OPERATORS :

Relational operators are used to compare variables or constants. In programming, relational operators are used to compare whether some variable value is higher, equal or lower with other variable. 'C' language provides following relational operators.

Operator name	Meaning
==	Equals
!=	Not Equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to

Relational operators can be used in an expression. The operands of relational operators can be constants, variables or expressions. The relational expression will have value either True (1) or False (0). Following are some examples of use of relational operators. For example, if a=2, b =3 and c=5 then,

a < b	(true)
5> 3	(true)
4 < 8	(true)
a >5	(false)
b< (a+c)	(true)

4.4 LOGICAL OPERATORS :

Sometimes in programming, we need to take certain action if some conditions are true or false. Logical operators help us to combine more than one condition, and based on the outcome certain steps are taken. 'C' language supports following logical operators.

Operator name	Meaning
&&	Logical AND
||	Logical OR
!	Logical NOT (Negation)

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Logical NOT is an unary operator. In an expression, we can use more than one logical operator. If than one operator is used, ! (NOT) is evaluated first, then && (AND) and then || (OR). We can parentheses to change the order of evaluation.

For example, if we have a=2, b=3 and c=5 then,

Expression	Value	Remark
a<b && c==5	true	both expression are true
! (5>3)	false	5>3 is true & negation of true is false
a< b || c>10	true	a<b is true which makes the expression true
(b> a)&&(c!=5)	false	c =5; so second condition false
(b<c||b>a)&&(c==5)	true	Both sub expression are true

4.5 ASSIGNMENT OPERATORS :

We have already used the assignment operator = in previous programs. 'C' language supports = assignment operator. It is used to assign a value to a variable. The syntax is

```
variablename = expression;
```

The expression can be a constant, variable name or any valid expression. In an expression involving arithmetic operators, assignment operator has the least precedence i.e +,-,*,/and % will be given more priority.

'C' language also supports the use of shorthand notation also. For example, the statement a=a+5 can be written using shorthand notation as a += 5. So, shorthand notation can be used for any statement whose form is

```
varname = varname operator expression;
```

into

```
varname operator= expression;
```

Use of shorthand notation makes your statement concise and program writing becomes faster particularly when the variable names are long in size.

Assignment operator	Shorthand
a = a +5;	a +=5;
a = a-5;	a -=5;
a = a*5;	a *=5;
a = a/5;	a /=5;
a = a%5; (assuming a as integer)	a %=5;

Program :

```
/* Program explaining short hand notations */
#include <stdio.h>
#include <conio.h>
main()
{
   int a;
   clrscr();
   printf("Give the value of a\n");
   scanf("%d",&a);
   a += 5;   /* a= a +5 */
```

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```
    printf("a=  %d\n",a);
    a  -=  5;   /*  a  =  a-5  */
    printf("a=  %d\n",a);
    a  *=5; /*  a  =  a*  5  */
    printf("a=  %d\n",a);
    a  /=5; /*  a=  a  /5  */
    printf("a=  %d\n",a);
    a  %=  5;   /*  a=  a  %5  */
    printf("a=  %d\n",a);
}
```

Output :

```
Give  the  value  of  a
4
a=  9
a=  4
a=  20
a=  4
a=  4
```

4.6 INCREMENT AND DECREMENT OPERATORS :

Sometimes we need to increase or decrease a variable by one. We can do that by using assignment operator =. For example, the statement a = a +1 increments the value of variable a, same way the statement a= a-1 decrements the value of variable a.

'C' language provides special operators ++ (increment operator) and — (decrement operator) for doing this. These operators are unary i.e it requires only one operand. The operand can be written before or after the operator. If a is a variable, then ++a is called prefix increment while a++ is called postfix increment. Similarly, —a is called prefix decrement while a— is called postfix decrement.

If the ++ or — operator is used in an expression or assignment, then prefix notation and postfix notation give different values. One should use prefix or postfix notation carefully in an assignment or expression involving other variables.

Program :

```
/* Program showing use of increment ++ and decrement — operators */
#include  <stdio.h>
#include  <conio.h>
main()
{
    int  x=10;
    int  y;
    int  z=0;
    clrscr();
    x++;  /*  x  incremented  using  postfix  notation  x=11*/
    ++x;  /*  x  incremented  using  prefix  notation  x=12*/
```

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```
    y = ++x;  /* x incremented first and then assigned
       to y. y=13   x=13 */
    printf("Value of x=%d y=%d and z=%d\n",x,y,z);
    z= y--;/* y assigned to z first and then decremented
       z=13 y =12*/
    printf("Value of x=%d y=%d and z=%d\n",x,y,z);
}
```

Output :

```
Value of x=13 y=13 and z=0
Value of x=13 y=12 and z=13
```

If we execute following code,

```
int x = 10;
void main()
    {
    int x = 15,y;
    y = x++;
    printf("%d %d",++y, x++);
}
```

In above program,

Statement	Effect
int x = 10;	x=10
int x = 15,y;	x=15 (local value in main()) y =random value
y = x++;	y=15 and x=16
printf("%d %d",++y, x++);	y incremented first so(y=16) , x printed first & then incremented

So, output

16 16

4.7 CONDITIONAL OPERATOR (TERNARY OPERATOR) :

'C' language provides ? operator as a conditional operator. It is also known as a **ternary** operator. It used as shown below.

```
expr1 ? expr2 :expr3;
```

where expr1 is a logical expression, logical expression can be TRUE or FALSE. expr2 and expr3 are expressions expr1 is evaluated first, and depending on its value TRUE or FALSE, either expr2 or expr3 is evaluated. If expr1 is TRUE, then expr2 is executed, otherwise expr3 is executed.

Actually, use of ternary operator is an alternative use of if..else statement, which we will study later.

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Program :

```
/* Write a program to find maximum and minimum of two numbers using ternary ? operator */
#include <stdio.h>
#include <conio.h>
main()
{
    int x,y,max,min;
    clrscr();
    printf("Give two integer numbers\n");
    scanf("%d%d",&x,&y);
    max = (x>y) ? x: y; /* x>y is a logical expression */
    min = (x<y) ? x: y; /* x<y is a logical expression */
    printf("maximum of %d and %d is = %d\n",x,y,max);
    printf("minimum of %d and %d is = %d\n",x,y,min);
}
```

Output :

```
Give two integer numbers
3 6
maximum of 3 and 6 is = 6
minimum of 3 and 6 is = 3
```

4.8 BITWISE OPERATORS :

We know that internally, the data is represented in bits 0 and 1. 'C' language supports some operators which can perform at the bit level. These type of operations are normally done in assembly or machine level programming. But, 'C' language supports bit level manipulation also, that is why 'C' language is also known as middle-level programming language.

Following table shows bit-wise operators with their meaning.

Operator name	Meaning
&	Bit-wise AND
|	Bit-wise OR
^	Bit-wise Exclusive OR (XOR)
<<	Left Shift
>>	Right Shift
~	Bit-wise 1's complement

One character requires 1 byte(8 bits) of storage, while integer requires 2 Bytes(16 bits). The individual bits are numbered as follows.

8 bit character

7 6 5 4 3 2 1 0

16 bit integer

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

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The bit numbering is from right to left.

Following table explains the basic &, | and ^ operations.

Bit1	Bit2	Bit1 & Bit2	Bit1 | Bit2	Bit1 ^ Bit2
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

Let us understand with an example.

```
char  x=15;
char  y=8;
char  z;
```

x will be represented in memory as bit sequence 0 0 0 0 1 1 1 1

y will be represented in memory as bit sequence 0 0 0 0 1 0 0 0

Following figure explains the various operations on x and y. The numbers written in brackets are the d numbers.

```
x      (15)   0 0 0 0 1 1 1 1
y       (8)   0 0 0 0 1 0 0 0
-----------------------------
z=x&y  (8)   0 0 0 0 1 0 0 0
x      (15)  0 0 0 0 1 1 1 1
y       (8)  0 0 0 0 1 0 0 0
-----------------------------
z = x^y (7)  0 0 0 0 0 1 1 1
```

```
x      (15)   0 0 0 0 1 1 1 1
y       (8)   0 0 0 0 1 0 0 0
-----------------------------
z=x|y  (15)   0 0 0 0 1 1 1 1
y       (8)   0 0 0 0 1 0 0 0
z= ~y  (245)  1 1 1 1 0 1 1 1
```

The << and >> operators are used to shift the bits in left and right directions respectively. After th or >> operator some integer number is written.

Example of <<

```
z = y << 1;
```

will shift the bits of y one bit in left side, and 0 is inserted from right side.

```
                ↓
y  (8)      0 0 0 0 1 0 0 0
z = y << 1(16) 0 0 0 1 0 0 0 0 ← inserted
```

So, we can see that the left shift by one bit multiplies the number by 2. If we left shift it by 2 bits, number is multiplied by 4.

Example of >>

```
z = y >> 2;
```

will shift the bits of operand y by 2 bit positions towards right side, and 0 is inserted from left sid

```
y  (8)          0 0 0 0 1 0 0 0
z = y >>2 (2)   0 0 0 0 0 0 1 0
                ↑
                inserted
```

Each one bit shift on right divides the number by 2. We shifted 2 bits towards right so y divided b Here, the answer may be truncated if the operand is not even number.

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Program :

```
/* Write a program to multiply and divide the given number by 2 using bit-wise operators << and >> */
#include <stdio.h>
#include <conio.h>
main()
{
    int x;
    int mul,div;
    clrscr();
    printf("Give one integer number\n");
    scanf("%d",&x);
    mul = x << 1; /* left shift */
    div = x >> 1; /* right shift */
    printf("multiplication of %d by 2 = %d\n",x,mul);
    printf("division of %d by 2 = %d\n",x,div);
}
```

Output-1 :

```
Give one integer number
5
multiplication of 5 by 2 = 10
division of 5 by 2 = 2
```

Output-2 :

```
Give one integer number
8
multiplication of 8 by 2 = 16
division of 8 by 2 = 4
```

Explanation :

In the first output, input is number 5 (odd number), so division operation output is truncated, while in second output, input is number 8(even number), so division operation produces correct answer 4.

4.9 OTHER SPECIAL OPERATORS :

'C' language provides other special operators. They are: comma operator, sizeof operator, arrow (->) operator, dot (.) operator , * operator and & operator. The arrow (->) operator and dot (.) operator are member selection operators used with a data structure called as structure, while * operator and & operator are normally used with pointer data type. We will see more detail about these 4 operators in detail in later chapters.

Comma operator

(,) Comma operator is used to combine multiple statements. It is used to separate multiple expressions. It has the lowest precedence. It is mainly used in for loop. We will study for loop in later chapters.

The expressions which are separated by comma operator are evaluated from left to right i.e. associativity of comma operator is from left to right.

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For example, the following statement

```
z = (x=5, x+5);
```

is equivalent to the statement sequence

```
x = 5;
z = x +5;
```

Program :

```
/* Program demonstrating comma operator (,) */
#include <stdio.h>
#include <conio.h>
main()
{
    int x,z;
    clrscr();
    z = (x=5 , x+5);   /* comma operator hare */
    printf("Value of z= %d\n",z);
}
```

Output :

```
Value of z= 10
```

sizeof operator :

sizeof operator is used to find out the storage requirement of an operand in memory. It is an unary operator which returns the size in bytes.

The syntax is sizeof(operand)

For example,

```
sizeof(float) returns the value 4
sizeof(int) returns the value 2
```

The statement sequence,

```
char c;
sizeof (c);
```

will return the value 1, because c is character type variable, and character requires one byte of memory.

4.10 PRECEDENCE AND ASSOCIATIVITY OF OPERATORS :

When arithmetic expressions are evaluated, the answer of that expression depends on the value of operands, the operators used and also on the precedence and associativity of the operators used. We have already seen what we mean by precedence of the operators, when we studied arithmetic and other operators in 'C', the operators having the same precedence are evaluated from left to right or right to left depending upon the level at which these operators belong.

For arithmetic operators,

Operators	Precedence	Associativity
* / %	first priority	Left to right
+ -	second priority	Left to right

Precedence and associativity of all operators is shown in following table.

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Operators	Associativity
( ) [ ] -> :: .	Left to right
! ~ ++ -- + - * sizeof	Right to left
* / %	Left to right
+ -	Left to right
<< >>	Left to right
< <= > >=	Left to right
== !=	Left to right
&	Left to right
^	Left to right
|	Left to right
&&	Left to right
?:	Left to right
= += *= -= %= ^= |= <<= >>=	Right to left
,	Left to right

From the associativity table, it is clear that unary operators like (+, -, *, sizeof, ! etc) have right to left associativity. Similarly, the assignment operators such as (=, *=, +=, -=, != etc) have right to left associativity.

Let us consider following example,

Assume a=6, b=4 and c=9

For the statement, `z = b-c *a;`

Will be evaluated as z = 4 – 9 * 6 = 4 – 54 = -50.

In the above expression – and * are two operators. The * operator has higher precedence than – operator, so c * a will be evaluated first, then + will be evaluated.

The expression,

5 -3 * 4 +6 /4 will be evaluated as 3 *4 first, then 6/4,then – operation and at last + operation as shown below.

5–3 * 4 + 6 /4

↓

5 – 12 + 6/4

↓

5 – 12 + 1

↓

-7 +1

↓

-6

In an expression, we can use the parenthesis to change the order of evaluation of sub expressions. For example, in the expression 4 * (3 +6) – (4 +3) the order of evaluation will be first (3 +6), then (4 +3), then 4 * result of (3+6) and finally the – operation will be done. So the answer will be 29.

4.11 SOLVED PROGRAMMING EXAMPLES :

Program :

```
/* Write a program to exchange two variables. */
#include <stdio.h>
#include <conio.h>
void main()
{
```

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```
    int  x,y,temp;
    clrscr();
    x=5;
    y=3;
        printf("Before  exchange  x  =%d  and  y  =%d\n",x,y);
    temp  =x;
    x  =  y;
    y  =  temp;
    printf("After  exchange    x  =%d  and  y  =%d\n",x,y);
}
```

Output :

```
Before  exchange  x=5  and  y=3
After  exchange    x=3  and  y=5
```

Program :

```
/* Write a program to exchange two variables without use of third variable */
#include  <stdio.h>
#include  <conio.h>
void  main()
{
    int  x,y;
    clrscr();
    x=5;
    y=3;
    printf("Before  exchange  x  =%d  and  y  =%d\n",x,y);
    x=x+y;
    y=x-y;
    x=x-y;
    printf("After  exchange    x  =%d  and  y  =%d\n",x,y);
}
```

Output :

```
Before  exchange  x  =5  and  y  =3
After  exchange    x  =3  and  y  =5
```

Program :

```
/* Write a program to calculate area, perimeter and diagonal length of rectangle of length l and width
b. Area = l *b   Perimeter = 2*l + 2*b
Diagonal Length = sqrt(l*l +b*b) */
#include  <stdio.h>
#include  <conio.h>
#include  <math.h>
```

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```
void main()
{
    int l,b;
    int area, peri;
    float d;
    clrscr();
    printf("Give length and width of rectangle\n");
    scanf("%d%d",&l,&b);
    area = l*b;
    peri = 2*l + 2*b;
    d = sqrt(l*l + b*b);
        /* find square root of number in brackets */
    printf("Area = %d Perimeter = %d Diagonal Length = %f\n",area,
    peri,d);
}
```

Output :

```
Give length and width of rectangle
3 5
Area = 15 Perimeter = 16 Diagonal Length = 5.830952
```

Program :

```
/* Write a program to evaluate the polynomial 3x^3 - 4x +9 */
#include <stdio.h>
#include <conio.h>
#include <math.h>
void main()
{
    float x, ans=0;
    clrscr();
    printf("Give value of x\n");
    scanf("%f",&x);
    ans = ans + 3 * x*x*x;
    ans = ans - 4*x;
    ans = ans +9;
    printf("Value of polynomial is = %6.2f\n",ans);
}
```

Output :

```
Give value of x
2
Value of polynomial is =    25.00
```

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: MCQs :

1. Which operator can be used only with integer numbers?
   (a) + (b) − (c) % (d) *
2. Which operator is used to find remainder after division?
   (a) * (b) / (c) − (d) %
3. What is the value of expression 5/9 in 'C'?
   (a) 0.556 (b) 0 (c) 1 (d) None of ab
4. Which operator has higher priority while evaluating arithmetic expression?
   (a) + (b) −
   (c) % (d) All have same priority
5. What is the symbol for logical OR operator?
   (a) != (b) & (c) && (d) ||
6. Which operator is unary?
   (a) −− (b) * (c) ++ (d) Both a and
7. What is the output of following code?

```
void main()
    {
    int x = 15,y;
    y = x++;
    printf("%d %d",++y, x++);
    }
```

   (a) 15 16 (b) 16 16 (c) 16 15 (d) None of ab
8. Which one is correct use of ternary operator?
   (a) expr1 ? expr2 : expr3; (b) expr1 ? expr2::expr3;
   (c) expr1 = expr2 :expr3; (d) expr1 : expr2 ? expr3;
9. What is value of z for following code?

```
int y=8;
z= y >> 2;
```

   (a) 8 (b) 2 (c) 4 (d) None of ab
10. Which operators have right to left associativity?
   (a) Arithmetic (b) Relational (c) Assignment (d) None of abo
11. 5 −3 * 4 +6 /4 evaluates to
   (a) 5 (b) −6 (c) 3.5 (d) None of abo
12. 4 * (3 +6) − (4 +3) evaluates to
   (a) 8 (b) 27 (c) 11 (d) None of abo
13. Type conversion is
   (a) Automatic (b) Manual (c) Both a and b (d) None of abo
14. To round off x, which is a float, to an int value, Which one is correct way?
   (a) y = (int)(x + 0.5) (b) y = int(x + 0.5)
   (c) y = (int)x + 0.5 (d) y = (int)((int)x + 0.5)
15. Which bitwise operator is suitable for checking whether a particular bit is on or off?
   (a) && (b) & (c) | (d) ||
16. Ternary operator operates on how many operators?
   (a) 2 (b) 1 (c) 3 (d) 4

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: ANSWERS :

1. (c)	**2.** (d)	**3.** (b)	**4.** (d)	**5.** (d)	**6.** (d)	**7.** (b)
8. (a)	**9.** (b)	**10.** (c)	**11.** (b)	**12.** (b)	**13.** (a)	**14.** (a)
15. (b)	**16.** (c)					

LONG QUESTION/ANSWERS

1. List the categories (various types) of operators in 'C' language.

Ans. : 'C' language supports rich set of operators. The operators can be divided into different categories as shown below.

- Arithmetic operators

  + - */%

- Relational operators

  = =(equality) != < > <= >=

- Logical operators

  &&(Logical AND) | | (Logical OR) !(Logical NOT)

- Assignment operators

  = (assignment)

- Increment and Decrement operators

  ++ (increment) — (decrement)

- Conditional operators (Ternary operator)

  ?

  expr1 ? expr2 :expr3;

where expr1 is a logical expression, logical expression can be TRUE or FALSE. expr2 and expr3 are expressions. expr1 is evaluated first, and depending on its value TRUE or FALSE, either expr2 or expr3 is evaluated. If expr1 is TRUE, then expr2 is executed, otherwise expr3 is executed.

- Bitwise operators

  & | ^ << >> ~

- Other special operators

  , (comma) . (dot) * (indirection) & (address of)

2. What is conditional operator? Write a small program using conditional operator.

Ans. : Conditional operators is also known as ternary operator ?

For example, the statement,

expr1 ? expr2 :expr3;

where expr1 is a logical expression, logical expression can be TRUE or FALSE. expr2 and expr3 are expressions. expr1 is evaluated first, and depending on its value TRUE or FALSE, either expr2 or expr3 is evaluated. If expr1 is TRUE, then expr2 is executed, otherwise expr3 is executed.

Following program finds maximum of two numbers using ? operator

```
#include <stdio.h>
main()
{
    int x,y,max;
    clrscr();
    printf("Give two integer numbers\n");
    scanf("%d%d",&x,&y);
    max = (x>y) ? x: y; /* x>y is a logical expression */
    printf("maximum of %d and %d is = %d\n",x,y,max);
```

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3. **What is type conversion? Explain implicit type conversion and explicit type conversion with exam**

Ans : Whenever an expression involves two different types of operands, 'C' language applies the type conver rules to evaluate an expression. At a time only one operator under consideration is taken. If the opera are of different type, then the operand with a lower type is upgraded to the higher type and then operation is performed. So, type conversion is implicit i.e automatic.

For example,

```
int  a,b;
float  c;
double  d;
.
.
.
b = a  *c  +d  /10;
```

In the above example, a*c will done first, and a will upgraded to float because 'c' is float type. Th d/10 will evaluated, 10 will be upgraded to 10.0 because 'd' is double.

Explicit type conversion is also known as type casting. Type casting is explicitly specified by the programm in the program.

Explicit type conversion is specified in following form:

(typename) expression;

For example, float(10) converts integer 10 to float 10.0

4. **Explain operator precedence and associativity.**

Ans : When arithmetic expressions are evaluated, the answer of that expression depends on the value of operand the operators used and also on the precedence and associativity of the operators used.

Precedence tells which operator has higher priority than other. For example, * / % operators hav higher precedence than + - operators.

While associativity tells in an expression if the operators having same priority occurs then which operato will be evaluated first? Some operators have left to right associativity while some have right to left associativit Following table shows partial table for associativity. The shortcut operators have right to left associativit

Operators	Associativity
* / %	Left to right
+ -	Left to right
= += *= -= %= ^= |= <<= >>=	Right to left

: SHORT QUESTIONS :

1. **Which arithmetic operator gives remainder after division?**

⇒ %

2. **Which relational operator is used to check equality?**

⇒ = =

3. **Which operator is known as ternary operator? What is its other name?**

⇒ ? is ternary operator. The other name of ternary operator is conditional operator.

4. **What is the use of sizeof operator?**

⇒ The sizeof operator is used to find the storage requirements of an operand in memory. It returns the size in bytes. Its syntax is: sizeof(operand)

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5. How type conversion and type casting are different?

⇒ Type conversion is automatic while type casting is explicitly specified by programmer in the program. Type casting syntax is : (typename) expression;

6. What are header files?

⇒ The files included at the beginning of a program and having an extension .h are called header files. They are included using preprocessor directive include. For example, #include <stdio.h>

7. What are macros?

⇒ Macros are abbreviations for lengthy and frequently used statements. When a macro is called the entire code is substituted by a single line though the macro definition is of several lines.

8. What is a preprocessor?

⇒ It is normally a part of the compiler which preprocesses the source code using its directives called as preprocessor directives. In 'C' language preprocessor directives begin with symbol #.

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Module-5

Arrays and Strings

5.1 ARRAY :

Array is a collection of variables of same type known by a single name. The individual elements of an array are referred by their index or sub-script value. The array is an important concept and helps the programmer in managing many variables of the same type, because all the elements of an array share a single name. Arrays can be divided into two categories

1. Single dimensional array
2. Multi-dimensional array

5.2 SINGLE DIMENSIONAL ARRAY :

The syntax for declaring a single dimensional array is :

```
datatype   arrayname[size];
```

Here, datatype defines the type of array elements, it can be int, char, float , long int etc. The arrayname is the name of a variable which represents the array, while size which is represented in [ ] symbols represents the size of array. If size is 10, it means the number of elements an array can store is 10.

For example,

```
int a[10];
```

here, int is datatype, a is the name of an array variable and 10 is the size of an array. It defines 10 integer variables, all known by variable name **a**. In 'C' language array index or subscript starts from 0. So, for above example, we have 10 different integer variables as a[0], a[1], a[2], a[3], a[4], a[5], a[6], a[7], a[8] and a[9], where a[0] is the first element of an array, while a[9] is the last element.

Graphically, array a can be represented like this.

Array elements

	a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]	a[8]	a[9]
	12	45	34	2	33	65	76	8	6	67
index	0	1	2	3	4	5	6	7	8	9

Figure 8.1

From figure 8.1, we can see that we have 10 different variables, a[0] to a[9]. Index value goes from 0 to 9. Element a[5] has value 65, element a[8] has value 6, while element a[0] has value 12. In a[5], 5 is the index value, similarly in a[8], 8 is the index value.

The array element can be used in any expression, just like a normal variable is used.

Following code of for loop reads 10 different integer numbers from keyboard and stores in array a.

```
for(i=0;i<10;i++)
      scanf("%d",&a[i]);
```

The above code stores the first number in a[0], second number in a[1] and 10th number in a[9]. Similarly following code of for loop will print the values of array a starting from a[0] to a[9].

```
for(i=0;i<10;i++)
      printf("%d",a[i]);
```

Let us write a small program which explains how we can store data in an array and use the array elements in a program.

Program :

```
/* Write a program to get n numbers and find out sum and average of numbers */
#include <stdio.h>
#include <conio.h>
main()
{
    int a[10];      /* array of size 10 defined */
    int i,n;
    float avg,sum =0;    /* sum initialized to 0 */
    clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
                /* store array elements in array a */
        sum = sum + a[i];
                /* go on adding array element to sum */
        }
    avg = sum/n;      /* sum over. Calculate average */
    printf("Array elements are :\n");
    for (i=0; i<n;i++)      /* print array elements */
          printf("%4d",a[i]);
    printf("\nSum = %f Average = %6.2f\n",sum,avg);
                              /* print answer */
}
```

Output :

```
Give value of n (not more than 10)
4.
Give number 12
Give number 15
Give number 20
Give number 18
Array elements are :
  12  15  20  18
Sum = 65.000000 Average =  16.25
```

Explanation :

In this program, we have declared an array of size 10. It means we can store only 10 integer numbers. For finding average, we need to sum all numbers. So, **sum variable is initialized to zero**. In for loop i variable

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goes from 0 to n-1, and we read n values one by one and go on adding into sum variable. When the for loop is over, we calculate average by using **avg=sum/n** statement. The avg variable is declared as floating because division of integer by integer can be float number.

The following code prints the array data and then prints the sum and average as result.

Note that in the for loop only one printf statement is there, while second printf statement is outside for loop.

```
for (i=0; i<n;i++)
      printf("%4d",a[i]);
printf("\nSum = %f Average = %6.2f\n",sum,avg);
```

Program :

```
/* Write a program using an array to find largest and smallest number from given n numbers. */
#include <stdio.h>
#include <conio.h>
main()
{
    int a[10];     /* array of size 10 defined */
    int i,n;
    int max,min;
    clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
        }
    max = a[0];       /* initialize min and max */
    min = a[0];
    for (i=1; i<n;i++)
        {
        if (max < a[i])
            max = a[i];
        if (min > a[i])
            min = a[i];
        }
    printf("Array elements are :\n");
    for (i=0; i<n;i++)
        printf("%4d",a[i]);
printf("\nLargest = %d Smallest = %d\n",max,min);
}
```


Output :

```
Give value of n (not more than 10)
5
Give number
2
Give number
4
Give number
7
Give number
8
Give number
-4
Array elements are :
   2   4   7   8  -4
Largest = 8 Smallest = -4
```

Explanation :

Here, max and min variable are used to store maximum and minimum values respectively. The input data is stored in an array using scanf() statement in for loop. Then max and min are initialized as the first value of array by following statements:

```
max = a[0];
min = a[0];
```

Then, in the for loop, which is written as below,

```
for (i=1; i<n;i++)
    {
    if (max < a[i])
        max = a[i];
    if (min > a[i])
        min = a[i];
    }
```

starting from index value 1 to n-1, each number is compared with max and min, if the current maximum or minimum is found, it is stored in corresponding max or min variable. So, max and min variable will always hold the current maximum and current minimum number found so far. When the for loop is over, the required answer is available in max and min variables, which are printed.

Program :

```
/* Write a program to find number of odd and even numbers from given n numbers.*/
#include <stdio.h>
#include <conio.h>
main()
{
```

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```
    int a[10];     /* array of size 10 defined */
    int i,n;
    int odd=0,even=0;  /* initialize counts */
    clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
        if (a[i] %2 == 0)
            even++;     /* increment even count */
        else
            odd++;     /* increment odd count */
        }
    printf("Array elements are :\n");
    for (i=0; i<n;i++)
        printf("%4d",a[i]);
    printf("\nNumber of ODDS = %d EVENS = %d\n",odd,even);
}
```

Output :

```
Give value of n (not more than 10)
7
Give number
2
Give number
4
Give number
3
Give number
1
Give number
5
Give number
6
Give number
7
Array elements are :
   2   4   3   1   5   6   7
Number of ODDS = 4 EVENS = 3
```


Explanation :

Here, we require to maintain two counters, one for odd numbers and other for even numbers. Following statement declares and initializes the counter to zero.

```
int odd=0,even=0;
```

In for loop, the numbers are read, and checked for odd or even by using % (modulo division) operator, and corresponding counter is incremented. The statements

```
for (i=0; i<n;i++)
    printf("%4d",a[i]);
printf("\nNumber of ODDS = %d EVENS = %d\n",odd,even);
```

prints the original list and the odd, even counts.

Program :

/* Write a program which declares array of 10 integers, enter the data and sum all the elements which are even. Also find the maximum number from the even numbers.*/

```
#include <stdio.h>
main()
{
    int a[10];     /* array of size 10 defined */
    int i,n;
    int sum=0,max=0;  /* initialize counts */

    printf("How many numbers?\n");
    scanf("%d",&n);  /* actual array size in n */

    for(i=0;i<n;i++)
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
        if (a[i] %2 == 0)
            {
            sum = sum + a[i];
            if (max < a[i])
            max = a[i];
            }
        }
    printf("Sum of even numbers = %d and maximum = %d",
    sum,max);
}
```

Output :

```
How many numbers?      8
Give number            2
Give number            4
Give number            5
Give number            6
Give number            8
Give number            7
Give number           12
Give number           56
Sum of even numbers = 88 and maximum = 56
```

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Program :

```
/* Delete a desired position element from array */
#include<stdio.h>
#include<conio.h>
void main()
{
    int a[20],i,n,pos,x;
    clrscr();
    printf("Enter how many values in array\n");
    scanf("%d",&n);
    printf("Enter %d values \n",n);
    for(i=0;i<n;i++)
        scanf("%d",&a[i]);
    printf("Which position value to be delete :");
    scanf("%d",&pos);
    printf("Your Existing List is :\n ");
        for(i=0;i<n;i++)
            printf("%5d",a[i]);
        for(i=pos-1;i<n;i++)
            a[i]=a[i+1];
        printf("\n\After deletion the list is .:\n ");
        for(i=0;i<n-1;i++)
            printf("%5d",a[i]);
    getch();
}
```

Output :

```
Enter how many values in array
6
Enter 6 values
16
26
36
46
56
66
Which position value to delete : 2
Your Existing List is :
    16    26    36    46    56    66
After deletion the list is :
    16  36  46    56    66
```


Program :

```
/* Write a program which finds maximum of N numbers and also finds how many times maximum is
repeated. */
#include <stdio.h>
main()
{
    int a[100],n,max,i, count;
    printf("How many numbers?");
    scanf("%d", &n);
    printf("Enter numbers\n");
    for(i=0;i<n;i++)
        scanf("%d",&a[i]);
    max = a[0];
    for(i=1;i<n;i++)
        {
        if (max < a[i])
            max = a[i];
        }
    count =0;
    for(i=0;i<n;i++)
        {
        if (max == a[i])
            count++;
        }
    printf("Maximum = %d and is repeated %d times\n",max,count);
    }
```

Output :

```
How many numbers?8
Enter numbers
12
34
23
34
32
4
34
24
Maximum = 34 and is repeated 3 times
```

SORTING THE LIST :

Suppose we want to arrange the numbers in either ascending or descending order. There are many algorithms available to do the sorting. In this program we will use the simplest algorithm.

In general, if there are n numbers in the list, then you require to make n-1 passes (scan the list n-1 times) and in each pass the smallest number is put at its correct position. It means that after every pass, one number is put at its correct position. In each pass this is done by exchanging the two numbers which are out of order (i.e larger number is above and smaller number is below if we are considering ascending order).

This can be explained by following example assuming n=4

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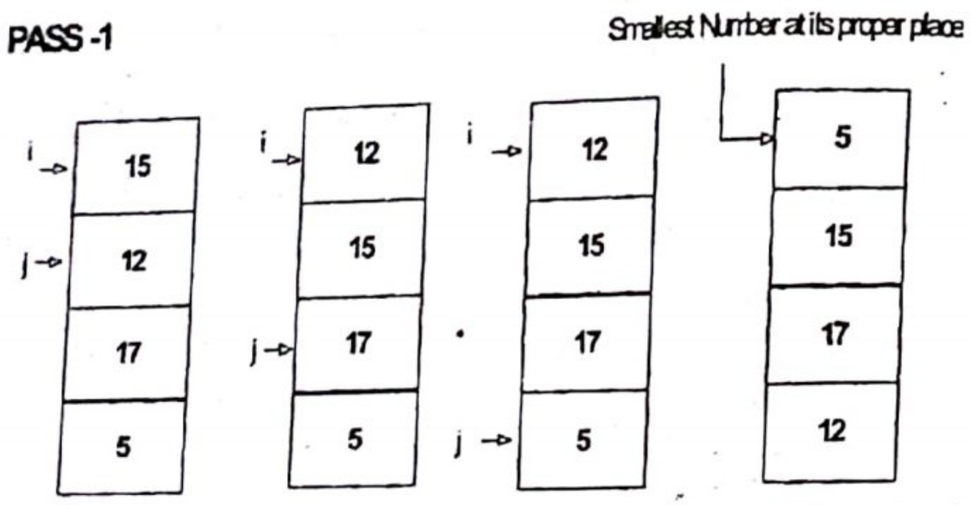
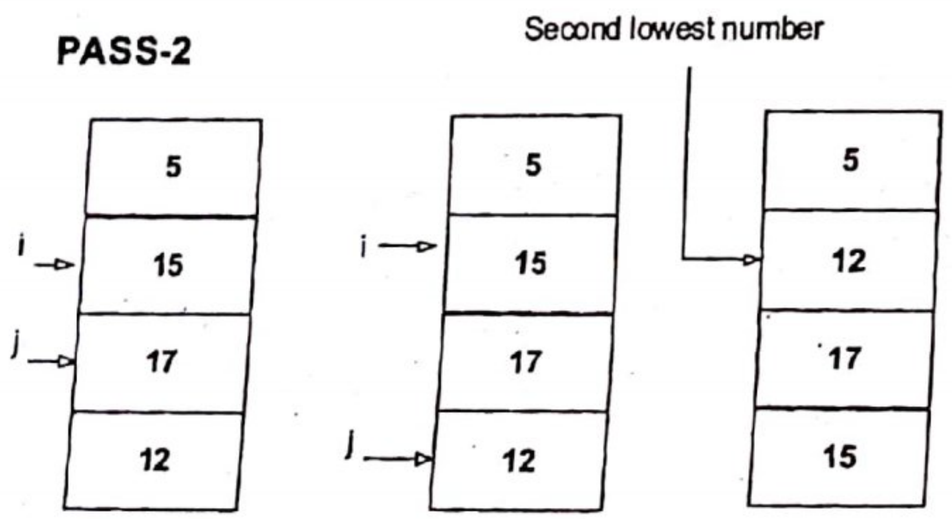
PASS -1



As shown above in pass 1, the numbers denoted by i and j are compared and if out of order, are exchanged. The i value indicates pass number.

PASS-2



As shown in pass 2, the numbers denoted by i and j are compared and if out of order, are exchanged. The i value indicates pass number.

Similarly, upto n-1 passes will be carried out to sort the list.

Program :

```
/* Write a program to sort given n numbers and display them in ascending and descending order. */
#include <stdio.h>
#include <conio.h>
main()
{
    int a[10];      /* array of size 10 defined */
    int i,j,n,temp;
    clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)    /* input data */
```



```
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
        }
    for(i=0;i<n-1;i++)
        {
        for(j=i+1;j<n;j++)
            {
            if (a[i]> a[j]) /* exchange two numbers */
                {
                temp = a[i];
                a[i] = a[j];
                a[j] = temp;
                }
            }
        }
    printf("Ascending order data is :\n");
    for (i=0; i<n;i++)  /* print from first to last */
        printf("%4d",a[i]);
    printf("\nDescending order data is :\n");
    for (i=n-1; i>=0;i-) /* print from last to first */
        printf("%4d",a[i]);
}
```

Output :

```
Give value of n (not more than 10)
7
Give number
-4
Give number
4
Give number
-3
Give number
6
Give number
20
Give number
16
Give number
10
```

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```
Ascending order data is :
  -4  -3   4   6  10  16  20
Descending order data is :
  20  16  10   6   4  -3  -4
```

Explanation :

In a particular pass i, the numbers which are out of order are exchanged by following piece of code.

```
if (a[i]> a[j])
{
temp = a[i];
a[i] = a[j];
a[j] = temp;
}
```

While, the loop **for(i=0;i<n-1;i++)** indicates pass number, and in each pass the numbers are compared by the loop **for(j=i+1;j<n;j++)**.

Once we get sorted data (ascending order data) in an array & print from first number to last, we get ascending order list as done by following code

```
for (i=0; i<n;i++)
    printf("%4d",a[i]);
```

If we print from last number to first, we get descending order list as done by following code

```
for (i=n-1; i>=0;i--)
    printf("%4d",a[i]);
```

5.3 INITIALIZATION OF SINGLE DIMENSIONAL ARRAY :

When the elements of the array are fixed & there is no need to take the values from keyboard, we can initialize the array in the program itself. For example, if you want to store number of days in each month from January to December, it can be initialized in the program itself while declaring array in the program.

In following program the line of code

```
int months[] = { 31,28,31,30,31,30,31,31,30,31,30,31};
```

does that. Here, months[] is a single dimensional array. Note that the brackets are not having the size value. There are total 12 values in the { }, so the size of the array will be automatically calculated.

While { 31,28,31,30,31,30,31,31,30,31,30,31} is the value of elements of an array. It means

```
months[0] = 31
months[1] = 28
.
.
.
months[10] = 30
months[11] = 31.
```

Same way, **int grp[] ={0,0,0};**

is also a single dimensional array whose value of all elements are initialized to zero. The size of this array is

3, because there are 3 categories, months of 28 days, 30 days &31 days.

The line

```
enum day {t8,t0,t1};
```

is user defined data type. **day** values can be t8(for two eight), t0(for three zero), t1(for three one). Here, t8 has value 0, t0 has value 1 while t1 has value 2.

In following program, grp[t8] (which is same as grp[0]) is a counter of 28 day month, grp[t0] (which is same as grp[1]) is a counter of 30 day months and grp[t1] (which is same as grp[2]) is a counter of 31 day months.

Program :

```
/* Write a program to give month numbers as input. Your program should group the month numbers according
to number of days.
For example, if the month number input are :
1 2 4 6 9
then no.of months of 31 day = 1
no. of months of 30 day = 3
no. of months of 28 day = 1   */
#include <stdio.h>
#include <conio.h>
enum day {t8,t0,t1};
main()
{
    int months[] =
            { 31,28,31,30,31,30,31,31,30,31,30,31};
    int grp[] ={0,0,0};
    int a[12];
    int i,n;
    clrscr();
    printf("Give total number of months n
                    (not more than 12)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)    /* input data */
        {
        printf("Give month number\n");
        scanf("%d",&a[i]);
        }
    for(i=0;i<n;i++)
        {
        if (months[a[i]-1] == 28)
            grp[t8]++;
        else if (months[a[i]-1] == 30)
            grp[t0]++;
```

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```
        else if(months[a[i]-1] == 31)
            grp[t1]++;

    printf("28 day month = %d 30 day month =
                                %d ",grp[t8],grp[t0]);
    printf("31 day month =%d\n",grp[t1]);
```

Output :

```
Give total number of months n (not more than 12)
5
Give month number
1
Give month number
2
Give month number
3
Give month number
4
Give month number
5
28 day month = 1 30 day month =1 31 day month =3
```

5.4 TWO DIMENSIONAL ARRAY :

Sometimes we need to store the data where more than one dimensions are involved, like sales information of a company, or for mathematical calculations we need to use matrix.

The syntax for two-dimensional array is :

```
datatype variablename[rowsize][colsize];
```

where, **variablename** represents the name of an array, **rowsize** indicate the number of rows in table, colsize indicates number of columns in an array.

In the case of a sales data of a company, each row lists items and columns represent the month name. The intersection of row and column represents the sales data for that particular item and month.

Sales data of company XYZ Ltd

Month / Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	50	60	70	55	44	55	55	44	33	55	33	101
B	10	12	12	12	03	13	16	19	20	21	25	20
C	01	02	40	40	50	32	34	40	33	38	45	49

To store the above type of data, we need to declare two-dimensional array as:

```
int sales[3][12];
```


Here, the row-size is 3, so row number spans from 0 to 2, while column number spans from 0 to 11.

← Column →

Row	0	1	2	3	4	5	6	7	8	9	10	11
0	50	60	70	55	44	55	55	44	33	55	33	101
1	10	12	12	12	03	13	16	19	20	21	25	20
2	01	02	40	40	50	32	34	40	33	38	45	49

In above figure, the cell a[i][j], refers to the cell in ith row jth column. So, a[0][0]=50, a[1][0] = 10, a[2][0] =01, a[1][5] = 13,a[1][11] =20, a[2][0]=01, a[2][2]=40,a[2][11]=49 & like that.

Similarly, in solving mathematical problems involving matrices, we can use two-dimensional array.

Program :

```
/* Write a program to add two given matrices. Matrices can be added only if number of columns are same
as well as number of rows are same in both matrices.
For example, if Matrix A[3][3] and matrix B[3][2] then, addition not possible because column values are
different.*/

#include <stdio.h>
#include <conio.h>
main()
{
    int a[4][4], b[4][4],c[4][4];
        /* matrix c stores result i.e c = a +b  */
    int m,n,p,q;
        /* m no.of rows in a, n no. of cols in a*/
    int i,j;  /* p no.of rows in b, q no. of cols in b*/
    clrscr();
    printf("Give number of rows in first matrix\n");
    scanf("%d",&m);
    printf("Give number of columns in first matrix\n");
    scanf("%d",&n);
    printf("Give number of rows in second matrix\n");
    scanf("%d",&p);
    printf("Give number of columns in second matrix\n");
    scanf("%d",&q);
    if( m!= p || n!= q) /* check size match or not */
        {
    printf("Size do not match. Addition not possible\n");
        return 0;
        }
    printf("Enter matrix A row-wise\n");
    for(i=0;i<m;i++)    /* Get first matrix data */
        {
```

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```
        for(j=0;j<n;j++)
            {
            printf("a[%d][%d]=   ",i,j);
            scanf("%d",&a[i][j]);
            }
        printf("\n");
        }
    printf("Enter matrix B row-wise\n");
    for(i=0;i<p;i++)    /* Get second matrix data */
        {
        for(j=0;j<q;j++)
            {
            printf("b[%d][%d]=   ",i,j);
            scanf("%d",&b[i][j]);
            }
        printf("\n");
        }
    printf("Matrix A \n");
    for(i=0;i<m;i++)
                /* display first matrix row-wise */
        {
        for(j=0;j<n;j++)
            printf("%4d",a[i][j]);
        printf("\n");
        }
    printf("Matrix B \n");
    for(i=0;i<p;i++)
                /* display second matrix row-wise */
        {
        for(j=0;j<q;j++)
            printf("%4d",b[i][j]);
        printf("\n");
        }
    printf("\nSum Matrix C \n");
    for(i=0;i<m;i++)
        /* calculate sum and display result matrix */
        {
        for(j=0;j<n;j++)
            {
            c[i][j] = a[i][j] + b[i][j];
            printf("%4d",c[i][j]);
            }
        printf("\n");
        }
}
```


Output-1 :

```
Give number of rows in first matrix
3
Give number of columns in first matrix
3
Give number of rows in second matrix
3
Give number of columns in second matrix
2
Size do not match. Addition not possible
```

Output-2 :

```
Give number of rows in first matrix
3
Give number of columns in first matrix
3
Give number of rows in second matrix
3
Give number of columns in second matrix
3
Enter matrix A row-wise
a[0][0]= 1
a[0][1]= 2
a[0][2]= 3
a[1][0]= 4
a[1][1]= 5
a[1][2]= 6
a[2][0]= 7
a[2][1]= 8
a[2][2]= 9
Enter matrix B row-wise
b[0][0]= 1
b[0][1]= 2
b[0][2]= 3
b[1][0]= 4
b[1][1]= 5
b[1][2]= 6
b[2][0]= 7
b[2][1]= 8
b[2][2]= 9
```

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```
Matrix A
1   2   3
4   5   6
7   8   9
Matrix B
1   2   3
4   5   6
7   8   9
Sum Matrix C
2    4   6
8   10  12
14  16  18
```

Program :

/* Write a program to read 5 * 5 matrix and find maximum number with its row and column index */

```
#include <stdio.h>
main()
{
        int a[5][5];
        int m,n;
        int i,j;
        int row,col,max;

        clrscr();
        printf("How many rows?\n");
        scanf("%d",&m);
        printf("How many columns?\n");
        scanf("%d",&n);

        printf("Enter matrix   row-wise\n");
        for(i=0;i<m;i++)    /* Get matrix data */
            {
            for(j=0;j<n;j++)
                {
                printf("a[%d][%d]=   ",i,j);
                scanf("%d",&a[i][j]);
                }
            printf("\n");
            }
        max = a[0][0];
        for(i=0;i<m;i++)
            {
            for(j=0;j<n;j++)
                {
                if (max < a[i][j])
                    {
                    max = a[i][j];
                    row=i;
```



```
                    col=j;
                    }
                }
            }
        printf("Maximum = %d at row = %d and column =%d \n",max,row+1,col+1);
        }
```

Output :

```
How many rows?    3
How many columns?   4
Enter matrix   row-wise
a[0][0]=   1
a[0][1]=   2
a[0][2]=   3
a[0][3]=   4

a[1][0]=   5
a[1][1]=   4
a[1][2]=   3
a[1][3]=   2

a[2][0]=   3
a[2][1]=   8
a[2][2]=   5
a[2][3]=   4
Maximum = 8 at row = 3 and column =2
```

5.5 INITIALIZATION OF TWO-DIMENSIONAL ARRAY :

The two dimensional array can be initialized at the time of declaration as in the case of single dimensional array. If the array has **m** rows and **n** columns, total elements of an array are **m*n**. If less than m*n values are used, then remaining values are treated as zero. For example,

```
int a[3][2] = { 0,0,1,1,2,2};
```

initializes first row data as {0,0}, second row data as {1,1}, third row data as {2,2}.

The above initialization is same as

```
int a[3][2] = {    {0,0},
                   {1,1},
                   {2,2}
              };
```

Suppose, we initialize as below, where less than 3*2 =6 values are given, then remaining elements will be treated as zero.

```
int  a[3][2]  =  {  0,0,1,1};
```

Here, only 4 elements are given, so last row data i.e third row data will be taken as {0,0}.

5.6 MULTI-DIMENSIONAL ARRAY :

In general, we can have n-dimensional array. If n≥2, then we call that array as multidimensional array. For example, suppose we want to store 5 students marks information for 2 different exams carried out in the term for 4 different subjects, this data can be stored by using 3-dimensional array like,

```
int marks[5][2][4];
```

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where, 5 students, 2 exams and 4 subjects. So, total entries in the array will be 5*2*4 = 40.

. The array will span from marks[0][0][0] to marks [4][1][3].

5.7 STRING :

String is a sequence of characters enclosed in double quotes. Normally string is useful for storing data like name, address, city etc. ASCII code is internally used to represent string in memory. In 'C' each string is terminated by a special character called null character. In 'C', null character is represented as '\0' or NULL. Because of this reason, the character array must be declared one size longer than the string required to be stored.

C O M P U T E R \0

Here, the string stored is "COMPUTER", which is having only 8 characters, but actually 9 characters are stored because of NULL character at the end.

```
char name[20];
```

This line declares an array name of characters of size 20. We can store any string up to maximum length 19.

String is basically an array of characters, so we can initialize the string by using the method of initializing the single dimensional array as shown below.

```
char name[] = { 'C', 'O' , 'M', 'P', 'U', 'T','E','R','\0'};
```

or

```
char name[] = "COMPUTER";
```

When the string is written in double quotes, the NULL character is not required, it is automatically taken.

5.8 READING STRINGS :

When we understood the scanf() statement, it was mentioned that it can also be used to read string from keyboard. The format specifier %s is used to read a string in the character array.

For example,

```
char name[20];
.
.
scanf("%s",name);
```

will read the string in the array name. There is no need to put & symbol before the name, beasuse name itself is the address of the string name.

We can also use the function gets() for reading a string. The array name should be written within brackets. For example,

```
char name[20];
.
.
gets(name);
```

The advantage of gets() is that we can read strings involving blanks, tabs. While the scanf() reads only upto blank or tab character. So, scanf() is used to read word while gets() can be used read sentence involving many words.

5.9 PRINTING STRINGS :

The string can be printed using printf() function with %s format specifier, or by using puts() function as shown below.

```
char name[] = "Sanjay";
.
.
printf("%s", name);
.
.
puts(name);
```

puts() can print only one string at a time, while one printf() can print multiple strings by using %s many times in the printf().

For example,

```
char name[] = "Sanjay";
char surname[] ="Shah";
.
.
printf("%s %s", name,surname);
.
.
puts(name);
puts(surname);
```

Here, one statement,

```
printf("%s %s", name,surname);
```

prints two strings, while two statements as shown below,

```
puts(name);
puts(surname);
```

are required to print name and surname using puts().

Program :

```
/* Write a program to find length of a given string */
#include <stdio.h>
#include <conio.h>
main()
{
    char str[30];      /* array of size 30 defined */
    int i,count =0;    /* initialize count to zero */
    clrscr();
```

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```
    printf("Give string \n");
    gets(str);
    for(i=0; str[i] != NULL,i++)
        count++;                    /* Increment count */
    printf("Length of string %s = %d\n",str,count);
}
```

Output :

```
Give string
vansh
Length of string vansh = 5
```

Explanation :

The count variable is initialized to zero. Then in for loop, we go on incrementing the count variable until the NULL value is found.

Program :

/* Write a program that takes a string and displays each character in one line with its ASCII value. */

```
#include <stdio.h>
#include <conio.h>
main()
{
    char str[30];     /* array of size 30 defined */
    int i;
    clrscr();
    printf("Give string \n");
    gets(str);
    for(i=0;i< str[i] != NULL;i++)
        printf("%c\t%d\n",str[i],str[i]);
}
```

Output :

```
Give string
Computer
C     67
o     111
m     109
P     112
u     117
t     116
e     101
r     114
```


Program :

/* Write a program that takes a string and reverses it. Display original string as well as reverse string. */

```
#include <stdio.h>
#include <conio.h>
main()
{
    char str[30], rev[30]; /* array of size 30 defined */
    int i,j,count=0;    /* initialize count to zero */
    clrscr();
    printf("Give string \n");
    gets(str);
    for(i=0;i< str[i] != NULL;i++)
                /* Get length of string in count */
        count++;
    for(i=count-1,j=0;i>=0;i-,j++)
    /* Last to first character stored in array rev */
        rev[j] = str[i];
    rev[j] = NULL;
        /* Terminate the reverse string with NULL */
    printf("Original string %s\t Reverse string %s\n",str,rev);
}
```

Output :

```
Give string
patan
Original string patan Reverse string natap
```

Explanation :

Length of string is found, then starting from the last character up to the first character are stored in array rev using following the code:

```
for(i=count-1,j=0;i>=0;i-,j++)
    rev[j] = str[i];
```

Here, **i variable works with str array, while j variable works with rev array.** Variable i goes from count-1 to 0, while j starts from 0 and goes on incrementing till the loop is over.

Following statement terminates the reversed string by putting NULL at the end.

```
rev[j] = NULL;
```

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5.10 STRING HANDLING BUILT-IN FUNCTIONS :

In this chapter, we have done many operations on strings by writing a code for getting length of string and to reverse a string.

We can do other operations on strings like copy a string, concate two strings and get one string, or compare two strings for equality. 'C' language provides this functionality by providing built-in functions for doing string processing. We require to include **string.h** header file for using built-in string functions.

Following table shows the important built-in library function with its meaning

Name of function	Syntax	Meaning	Example
strlen	strlen(s)	Finds the length of string s.	l=strlen("CP&U"); returns string length 4 in variable l.
strcpy	strcpy(dest,src)	Copies the string src to dest.	If dest="Jay" and src="kay" then strcpy(dest,src): makes dest="kay"
strcat	strcat(s1,s2)	Concate string s2 at the end of string s1.	If s1="Jay" and s2="kay" then strcat(s1, s2); makes s1 = "Jaykay"
strcmp	strcmp(s1,s2)	Compares string s1 with s2. If both are equal, it returns 0. If s1 alphabetically > s2, it returns positive number, otherwise returns negative number.	If s1="Jay" and s2="kay" then strcmp(s1, s2); returns-1 because "kay" is alphabetically greater than "jay"
strrev	strrev(s)	Reverses the string s, the original string is overwritten.	If s="Jay" then strrev(s): makes s = "yaj"
strcmpi	strcmpi(s1,s2)	Compares string s1 with s2 **ignoring the case.** If both are equal, it returns 0. If s1 alphabetically > s2, it returns positive number, otherwise returns negative number.	If s1="Jay" and s2= "kay" then strcmp(s1, s2); returns-1 because "kay" is alphabetically greater than "jay"
strncmp	strncmp(s1,s2,n)	Compare first n characters of s1 and s2 and return result similar to strcmp	If s1="Jay" and s2="kay" then strcmp(s1, s2,2); returns - 1 because "ka" is alphabetically greater than "Ja"
strupr	strupr(s)	Convert string s to uppercase	If s="Jay" then strupr(s); makes s = "Jay"
strlwr	strlwr(s)	Convert string s to lowercase	If s="Jay" then strupr(s); makes s="jay"
strstr	strstr(s1,s2)	Returns a pointer to the first occurrence of string s2 in s1	If s1="Jay" and s2="kay" then strstr(s1, s2); returns NULL be-cause string "kay" does not occur in "Jay"

Program :

```
/* Program demonstrating built-in string functions. */
#include <stdio.h>
#include <conio.h>
#include <string.h>
main()
```



```
{
   int i;
   char str1[20]= "COMPUTER";    /* size 20 */
   char str2[20]= "computer";
   clrscr();
   printf("Length of string %s = %d\n",str1, strlen(str1));
      /* strlen(str1) finds length of string str1 */
   i = strcmp(str1,str2);
            /* compare two string str1 and str2 */
   if (i==0)          /* return value 0 if strings
                         equal otherwise not equal */
        printf("Two string are equal\n");
   else
        printf("Two string are not equal\n");
   printf("Reverse of %s is ",str1);
   strrev(str1);
        /* reverse string str1 and replace str1 */
   printf(" = %s\n", str1);
   strrev(str1);
    /* again reverse str1, so str1 has original value */
   printf("concate of %s and %s ",str1,str2);
   strcat(str1,str2);
     /* concate str2 after str1. size of str1 increases */
   printf(" = %s", str1);
}
```

Output :

```
Length of string COMPUTER = 8
Two string are not equal
Reverse of COMPUTER is = RETUPMOC
concate of COMPUTER and computer = COMPUTERcomputer
```

Program :

```
/* Program to extract M character from a string */
#include<stdio.h>
#include<string.h>
#include<conio.h>
main()
{
   char  str[100];
```

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```
    int x,i,y,l;
    clrscr();
    printf("Enter the string\n");
    gets(str);
    l=strlen(str);          /* length of string */
    printf("How many characters you want to extract?    ");
    scanf("%d",&x);         /* Number of characters to be extracted */
    printf("From where to ?    " );
    scanf("%d",&y);         /* from position */
    printf("The extracted part of string is=\n");
    for(i=y-1; i<y+x-1; i++)
    printf("%c\n",str[i]);
    getch();
}
```

Output :

```
Enter the string
computer
How many characters you want to extract? 3
From where to ? 3
The extracted part of string is=
p
u
t
```

5.11 SOLVED PROGRAMMING EXAMPLES :

Program :

/* Write a program to search number x from given n numbers. If x is found, display the position within an array also. */

```
#include <stdio.h>
#include <conio.h>
main()
{
    int a[10];      /* array of size 10 defined */
    int i,n,x;      /* x is the number to be searched */
        clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)     /* input data */
      {
      printf("Give number\n");
```



```
      scanf("%d",&a[i]);
      }
    printf("Which number to be searched?\n");
    scanf("%d",&x);
    for(i=0;i<n;i++)
      {
      if (a[i] == x)
        {
        printf("%d found at position %d\n",x,i+1);
        break;  /* number found, no need to
                   check other numbers */
        }
      }
    if ( i == n)
                   /* whole array searched */
      printf("%d not in list\n",x);
}
```

Output-1 :

```
Give value of n (not more than 10)
6
Give number
2
Give number
3
Give number
7
Give number
5
Give number
4
Give number
10
Which number to be searched?
9
9 not in list
```

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Output-2 :

```
Give value of n (not more than 10)
6
Give number
2
Give number
3
Give number
7
Give number
5
Give number
4
Give number
10
Which number to be searched?
5
5 found at position 4
```

Explanation :

After storing the list and the number to be searched in x, we compare each number of list with x in for loop. If number found, then we break the loop and print the message using the value of i for finding the location of x number in list.

Program :

/*Write a C program to accept a string and print every third character from string only if it is lower case. */

```
#include<stdio.h>
#include<string.h>
main()
{
    char  s[20];
    int  i,len;
    printf("Give  one  string\n");
    gets(s);

    len  =  strlen(s);
        for(i=2;i<len;i=i+3)
        {
```



```
        if (islower(s[i])) /* is the character lowercase ? */
            printf("%c",  s[i]);
        }
}
```

Output 1 :

```
Give  one  string
ComputER
m
```

Output 2 :

```
Give  one  string
Computer
mt
```

Program :

/* Write a program to insert a number at a specified array index position*/

```
#include  <stdio.h>
#include  <conio.h>
main()
{
    int a[10];     /* array of size 10 defined */
    int i,n,x,pos; /* x is the number to be inserted */
            /* pos is the index value at which number
            is to inserted */
    clrscr();
    printf("Give value of n (not more than 10)\n");
    scanf("%d",&n);  /* actual array size in n */
    for(i=0;i<n;i++)    /* input data */
        {
        printf("Give number\n");
        scanf("%d",&a[i]);
        }
    printf("Which number to be inserted?\n");
    scanf("%d",&x);
    printf("At what index value(< 10 and must be between 0 and %d)
    ?\n",n-1);
    scanf("%d",&pos);
    if(pos <0 || pos >n-1)
```

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```
        {
        printf("Wrong input \n");
        return 1;
        }
    for(i=n;i>pos;i--)
        a[i] = a[i-1];
    a[pos] = x;
    n = n +1;
    printf("Array after insertion of %d at index %d\n",x,pos);
    for(i=0;i<n;i++)
        printf("%4d",a[i]);
}
```

Output :

```
Give value of n (not more than 10)
5
Give number
4
Give number
27
Give number
16
Give number
25
Give number
20
Which number to be inserted?
15
At what index value(< 10 and must be between 0 and 4)?
2
Array after insertion of 15 at index 2
   4  27  15  16  25  20
```

Explanation :

If we have to insert the number in the list at specific position, then we have to make that position vacant i.e the numbers below that position need to be shifted down. For that to avoid loss of data we start shifting from the last number upto specified position. That is achieved by the code:

```
for(i=n;i>pos;i--)
    a[i] = a[i-1];
```


After the insertion of data in an array, the number of elements in array increases by 1, so the statement

```
n = n +1;
```

Program :

```
/* Write a program to read n * n matrix. Display original matrix as well as its transpose matrix.
Transpose matrix can be derived by interchanging ith row data with ith column data i.e ith row values become
ith column values, while ith column values become ith row values.
Example, if a[3][3] = 1 2 3   then its transpose matrix = 1 4 7
                      4 5 6                               2 5 8
                      7 8 9                               3 6 9
*/
#include <stdio.h>
#include <conio.h>
main()
{
    int a[4][4];
    int n;
    /* assuming rows and columns same i.e n *n matrix*/
    int i,j;
    clrscr();
    printf("Give value of n\n");
    scanf("%d",&n);
    printf("Enter matrix A row-wise\n");
    for(i=0;i<n;i++)    /* Get first matrix data */
        {
        for(j=0;j<n;j++)
            {
            printf("a[%d][%d]=  ",i,j);
            scanf("%d",&a[i][j]);
            }
        printf("\n");
        }
    printf("Matrix A \n");
    for(i=0;i<n;i++)
                /* display first matrix row-wise */
        {
        for(j=0;j<n;j++)
            printf("%4d",a[i][j]);
        printf("\n");
        }
    printf("Transpose of A \n");
    for(j=0;j<n;j++)
                /* display second matrix row-wise */
```

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```
        {
        for(i=0;i<n;i++)
        printf("%4d",a[i][j]);
        printf("\n");
        }
}
```

Output :

```
Give value of n
3
Enter matrix A row-wise
a[0][0]=  1
a[0][1]=  2
a[0][2]=  3
a[1][0]=  4
a[1][1]=  5
a[1][2]=  6
a[2][0]=  7
a[2][1]=  8
a[2][2]=  9
Matrix A
1   2   3
4   5   6
7   8   9
Transpose of A
1   4   7
2   5   8
3   6   9
```

Program :

```
/* Write a program to read n * n matrix and check for symmetric square matrix.
In symmetric square matrix, ith row data is same as ith column data.
In other words a[i][j] = a[j][i] for all value of i and j.
Example, if a[3][3] =  1 2 3  is symmetric square, because a[i][j]=a[j][i]
                       2 5 8
                       3 8 9
*/
#include <stdio.h>
#include <conio.h>
main()
{
    int a[4][4];
```



```
int n;
/* assuming rows and columns same i.e n *n matrix*/
int i,j,flag=0;
clrscr();
printf(„Give value of n\n");
scanf("%d",&n);
printf("Enter matrix A row-wise\n");
for(i=0;i<n;i++)    /* Get matrix data */
    {
    for(j=0;j<n;j++)
        {
        printf("a[%d][%d]=  ",i,j);
        scanf("%d",&a[i][j]);
        }
    printf("\n");
    }
printf("Matrix A \n");
for(i=0;i<n;i++)    /* display matrix row-wise */
    {
    for(j=0;j<n;j++)
        printf("%4d",a[i][j]);
    printf("\n");
    }
for(i=0;i<n;i++)
    {
    for(j=0;j<n;j++)
        if (a[i][j] != a[j][i])
                        /* check condition */
            {
            flag = 1;
          /* set flag and come out of inner loop*/
            break;
                /* control goes to outer loop */
            }
      if(flag==1)    /* used to avoid unnecessary
                        iteration of outer loop */
          break;
      }
  if(flag ==1)
```

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```
        printf("Given matrix is not symmetric\n");
    else
        printf("Given matrix is symmetric\n");
}
```

Output :

```
Give value of n
3
Enter matrix A row-wise
a[0][0]=  1
a[0][1]=  2
a[0][2]=  3
a[1][0]=  2
a[1][1]=  5
a[1][2]=  8
a[2][0]=  3
a[2][1]=  8
a[2][2]=  9
Matrix A
1   2   3
2   5   8
3   8   9
Given matrix is symmetric
```

Program :

/* Write a program that counts number of words in a string and also print each word on separate line. */

```
#include <stdio.h>
#include <conio.h>
main()
{
    char str[30];     /* array of size 30 defined */
    int i,count=1;   /* count initialized to 1,
                        minimum one word */
    clrscr();
    printf("Give string \n");
    gets(str);          /* string in str array */
```



```
    for(i=0;i< str[i] != NULL;i++)
        {
        if (str[i] == ' ' || str[i] == '\t' )
                    /* check for word separator */
            {
            printf("\n");          /* word over */
            count++;
            }
        else
            printf("%c",str[i]);
                /* simple character, print it */
        }
    printf("\nNumber of words = %d\n",count);
}
```

Output :

```
Give string
Gandhinagar is the capital of Gujarat
Gandhinagar
is
the
capital
of
Gujarat
Number of words = 6
```

Explanation :

Words are separated by spacebar or tab character. In for loop, we check for tab or space bar. If it is found, it means the previous word is over and new word starts, so count variable is incremented. If the character is other than tab or space bar, then it is printed as a part of the word on the same line.

Program :

/* Write a program that converts given string into upper case and lower case.
ASCII value of A = 65, B=66,...Z=90
ASCII value of a = 97, b=98,...z=122
So, difference between ASCII value of second alphabet and first alphabet is 97-65 =32 */

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

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```
{
    char str[20],ustr[20],lstr[20];
                    /* array of size 20 defined */
    int i,count=0;     /* count initialized to 0 */
    clrscr();
    printf("Give string \n");
    gets(str);          /* string in str array */
    for(i=0;i< str[i] != NULL;i++)
        {
        if ( str[i] >= 'a' && str[i] <='z')
                        /* check for lower case */
            ustr[i] = str[i] - 32;
                            /* convert to upper */
        else
            ustr[i] = str[i];
        if ( str[i] >= 'A' && str[i] <='Z')
                        /* check for upper case */
            lstr[i] = str[i] + 32;
                        /* convert to lower */
        else
            lstr[i] = str[i];
        }
    lstr[i] = NULL;
        /* put NULL character at end in both array*/
    ustr[i] = NULL;
    printf("\nOriginal String is %s\n",str);
    printf("\Upper Case String is %s\n",ustr);
    printf("\Lower Case String is %s\n",lstr);
}
```

Output :

```
Give string
Computer
Original String is Computer
Upper Case String is COMPUTER
Lower Case String is computer
```

Explanation :

Here, 'a' stands for ASCII value of character a (i.e 97), same way 'z' stands for ASCII value of character z (i.e 122). Similarly for 'A' =65 and 'Z' =90. The array **ustr** stores the uppercase string, while array **lstr** store the lowercase string.

Program :

```
/* Write a menu driven program to perform string operations like length, reverse, copy, concate and compare
using built-in string functions */
#include <stdio.h>
#include <conio.h>
#include <string.h>
main()
{
    char str1[20],str2[20];
                    /* array of size 20 defined */
    int choice,len;
    clrscr();
    do
        {
        printf("1. String length     2. String reverse\n");
        printf("3. String copy  4. String Concate\n");
        printf("5. String compare  6. Exit\n");
        printf("Give your choice(1 to 6)\n\n");
        scanf("%d",&choice);
        switch(choice)
        {
        case 1:
        case 2:
        case 3:
            printf("Give string\n");
            scanf("%s",str1);
            if (choice ==1)
                {
                len = strlen(str1);
                printf("Length = %d\n",len);
                break;
                }
            else if (choice ==2)
                {
                strcpy(str2,str1);
                strrev(str2);
                printf("Reverse string = %s\n",str2);
                break;
```

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```
        else
          {
          strcpy(str2,str1);
          printf("Copied string = %s\n",str2);
          break;
          }
    case 4:
    case 5:
      printf("Give first string\n");
      scanf("%s",str1);
      printf("Give second string\n");
      scanf("%s",str2);
      if (choice ==4)
        {
        strcat(str1,str2);
        printf("Concated string = %s\n",str1);
        break;
        }
      else
        {
        if (strcmp(str1,str2) == 0)
          {
          printf("Two strings are equal\n");
          break;
          }
        else
          {
          printf("Two strings are not equal\n");
          break;
          }
        }
      }
  } while (choice != 6);
}
```

Output-1 :

```
1. String length      2. String reverse
3. String copy        4. String Concate
5. String compare     6. Exit
```



```
Give your choice(1 to 6)
1
Give string
computer
Length = 8
1. String length      2. String reverse
3. String copy        4. String Concate
5. String compare     6. Exit
Give your choice(1 to 6)
6
```

Output-2 :

```
1. String length      2. String reverse
3. String copy        4. String Concate
5. String compare     6. Exit
Give your choice(1 to 6)
4
Give first string
computer
Give second string
keyboard
Concated string = computerkeyboard
1. String length      2. String reverse
3. String copy        4. String Concate
5. String compare     6. Exit
Give your choice(1 to 6)
5
Give first string
computer
Give second string
mouse
Two strings are not equal
1. String length      2. String reverse
3. String copy        4. String Concate
5. String compare     6. Exit
Give your choice(1 to 6)
6
```

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Explanation :

do...while loop is used to repeatedly display the menu, the loop is over when user gives the choice 6. In do... while loop, the switch statement checks for choice and accordingly it asks for either one input string or two string input.

For choice 1, 2 & 3 only one string is required, while choice 4 and 5, two strings are required. Then according to the choice given by user, appropriate string function is called and the work is done and message printed using printf() statement.

Program :

```
/* Write a program to store n number of strings and then search the given string. */
#include <stdio.h>
#include <conio.h>
#include <string.h>
main()
{
    char names[10][20];
    char str[20];
    int i,n;
    int flag =0;
    clrscr();
    printf("How many strings\n");
    scanf("%d",&n);
    printf("Enter strings\n");
    for(i=0;i<n;i++)
        scanf("%s",names[i]);
    printf("Given strings are:\n");
    for(i=0;i<n;i++)
        printf("%s\t",names[i]);
    printf("\nEnter the string you want to search\n");
    scanf("%s",str);
    for(i=0;i<n;i++)
        {
        if (strcmp(names[i],str) == 0)
            {
            flag =1;
            break;
            }
        }
    if (flag ==1)
        printf("Found !! Given string %s found in list\n",str);
    else
        printf("Sorry !! Given string %s not found in list\n",str);
}
```


Output-1 :

```
How many strings
5
Enter strings
mumbai
ahmedabad
patan
surat
mahesana
Given strings are:
mumbai    ahmedabad    patan    surat    mahesana
Enter the string you want to search
patan
Found !! Given string patan found in list
```

Output-2 :

```
How many strings
5
Enter strings
mumbai
ahmedabad
patan
visnagar
surat
Given strings are:
mumbai    ahmedabad    patan    visnagar    surat
Enter the string you want to search
gandhinagar
Sorry !! Given string gandhinagar not found in list
```

Explanation :

To store more than one string, we require to use two-dimensional array of characters. The line

```
char names[10][20];
```

declares 2-dimensional array which can store 10 names, each name can be of maximum 20 characters. It means that above declaration is of 10 arrays each of size 20 characters.

The code

```
for(i=0;i<n;i++)
    scanf("%s",names[i]);
```

gets n different strings from user & stores them in an array. **Here, names[i] is equivalent to &names[i][0].** So, there is no need to put & symbol before names[i]. Why? It will become clear when we study the pointers in detail.

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The string to be searched is stored in array str. Then, the string str is searched one by one from names[][]. If string is found, flag variable is made 1 and loop terminated by break i.e there is no need to search remaining numbers. Appropriate message printed, which depends on the value of flag variable.

```
/* Write a program which accepts a long string and print only characters at positions which are multiple of 3. */

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

void  main()
{
    char  str[25];
    int  i=2,len;  /*  i  indicates  third  character  */
    clrscr();
    printf("Enter  a  string:    ");
    gets(str);
    len=  strlen(str);

    while  (i<len)
        {
        putchar(str[i]);
        i  =  i+3;  /*  next  multiple  of  three  */
        }
    getch();
}
```

Output :

```
Enter  a  string:    computer
mt
```


: MCQs :

1. Which declaration of array is correct?
   (a) int a(10); (b) int a{10}; (c) int a[10]; (d) int [10] a
2. What will happen if you assign a value to an array element whose subscript value exceeds the size of array?
   (a) Compiler will report an error (b) It may crash the program
   (c) Size will be automatically adjusted (d) 0 value assigned
3. What is the size of an array which is initialized like?
   int a[] = { 31,28,31,30,31,30,31,31,30,31,30,31};
   (a) Syntax error (b) 0 (c) 12 (d) 11
4. Which declaration of two dimensional array is correct?
   (a) sales[5][5]; (b) sales [5,5]; (c) sales (5,5) (d) None of above
5. In declaration int a[12][10]; how many elements are declared?
   (a) 22 (b) 99 (c) None of above
6. If we initialize the two dimensional array as
   int a[3][2] = { 0,0,1,1};
   what will be the value of a[2][1]?
   (a) Syntax error in initialization (b) 0
   (c) Random value (d) 1
7. Every string is terminated by NULL character. How it is represented?
   (a) '\0' (b) NULL (c) Both a and b (d) None of above
8. If we want to read a sentence having blanks, tabs we need to use
   (a) scanf() (b) gets() (c) Both a and b
9. How many arguments are required by built-in strlen() function?
   (a) 1 (b) 2 (c) 3 (d) 0
10. Built-in function strcpy(str1,str2) copies string
    (a) str1 to str2 (b) str2 to str1 (c) None of above
11. Array index start at
    (a) 1 (b) User defined (c) 0 (d) None of above
12. String handling built-in functions are defined in
    (a) conio.h (b) stdio.h (c) stdlib.h (d) None of above
13. If an array is declared as double a[5], how many bytes are allocated?
    (a) 5 (b) 10 (c) 20 (d) 40
14. ASCII code for a-z ranges from
    (a) 0-26 (b) 97-123 (c) 65-91 (d) None of above

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15. Function to add a string at the end of another string is
    (a) stradd() (b) strcpy() (c) strcat (d) strstr()
16. Which of the following function is more appropriate for reading in a multiword string?
    (a) printf() (b) scanf() (c) gets() (d) puts
17. What will be the output of following program

```
#include
main()
{
int x, y = 10;
x = y * NULL;
printf("%d",x);
}
```

    (a) error (b) 0 (c) 10 (d) garbage value
18. ASCII code for A–Z ranges from
    (a) 0–26 (b) 97–123 (c) 65–91 (d) None of above
19. ASCII code for 0–9 ranges from
    (a) 0–26 (b) 97–123 (c) 65–91 (d) 48–57

: ANSWERS :

1	(c)	2	(b)	3.	(c)	4.	(a)	5.	(c)	6	(b)	7	(c)
8.	(b)	9.	(a)	10.	(b)	11	(c)	12	(d)	13.	(c)	14.	(b)
15.	(c)	16	(c)	17	(a)	18.	(c)	19.	(d)				

LONG QUESTION/ANSWERS

1. What is a string? What are the operations that can be performed on string?

Ans:

String is a sequence of characters enclose in double quotes. Normally string is useful for storing data like name, address, city etc. ASCH code is internally used to represent string in memory. In 'C' each string is terminated by a special character called null character. In 'C', null character is represented as '\0' or NULL. Because of this reason, the character array must be declared one size longer than the string required to be stored.

C	O	M	P	U	T	E	R	\0

Here, the string stored is "COMPUTER", which is having only 8 characters, but actually 9 characters are stored because of NULL character at the end.

Operations on strings:

1. String Concatenation
2. String Copy
3. String Length
4. Compare two string
5. Reverse a string
6. Convert string to upper case
7. Convert string to lower case

2. Write a program to multiply two matrices A and B of size 3 * 3 and store the answer in matrix C. Le C = A * B.

Ans:

```
#include<stdio.h>
void main()
{
    int a[3][3], b[3][3], c[3][3];
    int m,n,o,p;
    int i,j,k;
    clrscr();
    printf("how many rows in first matrix?\n");
    scanf("%d",&m);
    printf("how many columns in first matrix?\n");
    scanf("%d", &n);
    for(i=0;i<m;i++)
    for(j=0;j<n;j++)
    {
    printf("Enter value of a[%1d][%1d]\n",i+1,j+1);
    scanf("%d",&a[i][j]);
    }
    printf("how many rows in second matrix?\n");
    scanf("%d",&o);
    printf("how many columns in second matrix?\n");
    scanf("%d", &p);
    if (n !=o ) /* number of columns of A and number
                of rows in B should match */
        {
        printf("Multiplication not possible.
            The columns of first\n");
        printf("matrix should be same as rows of
            second\n");
        return;
        }
    for(i=0;i<m;i++)
    for(j=0;j<n;j++)
    {
        printf("Enter value of a[%1d][%1d]\n",i+1,j+1);
        scanf("%d",&a[i][j]);
        }
    for(i=0;i<o;i++)
```

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```
        {
        for(j=0;j<p;j++)
        {
        printf("Enter value of
        b[%1d][%1d]\n",i+1,j+1);
        scanf("%d",&b[i][j]);
    }
  for(i=0;i<m;i++)  /* C matrix of size  m*p*/
        {
        for(j=0;j<p;j++)
        {
              c[i][j]=0;
              for(k=0;k<n;k++)
                    c[i][j]= c[i][j]+ a[i][k]*b[k][j];
        }
        }
  printf("Matrix A\n");
  for(i=0;i<m;i++)
  {
  for(j=0;j<n;j++)
        printf("%4d ",a[i][j]);
    printf("\n");
  }
        printf(„Matrix B\n");
  for(i=0;i<o;i++)
  {
  for(j=0;j<p;j++)
        printf(„%4d „,b[i][j]);
    printf(„\n");
  }
        }
  printf("Matrix C= A*B\n");
  for(i=0;i<m;i++)
  {
        for(j=0;j<p;j++)
              printf(„%4d „,c[i][j]);
        printf("\n");
  }
}
```


3. Write a program that read two strings and compare them using the function strcmp() and print the message that first string is equal, less, greater than second one.

Ans : Following program explains the use of strcmp() built-in library function.

```
#include<stdio.h>
void main()
{
      char str1[50], str2[50];
      int ans;
      clrscr();
      printf("Give first string\n");
      gets(str1);
      printf("Give second string\n");
      gets(str2);
      ans = strcmp(str1,str2);
      if (ans == 0)  /* both equal */
            printf("Both string %s and %s are
            equal\n",str1,str2);
      else if (ans > 0) /* first greater */
            printf("First string %s is greater than second
            %s\n",str1,str2);
      else /* second greater */
            printf("First string %s is less than second
            %s\n",str1,str2);
}
```

4. Write a 'C' program to read an array of integers and print its elements in reverse order.

Ans:

```
#include<stdio.h>
void main()
{
      int i;
      int a[100];
      int n;
      printf( How many numbers? \n");
      scanf("%d", &n);
      for(i=0;i<n;i++)
            {
            printf("\nGive number %d: ", i+1);
```

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```
        scanf("%d", &a[i]);
        }
        printf("\nThe list in reverse order is\n");
    for(i=n-1;i>=0;i--)
        printf("\n%d", a[i]);
}
```

5. Find out the error if any in following code and correct it and give output.

```
void main()
{
int iNo[3] = {10,20,30,40};
char cName[]="exam";
char cNidd[]="university";
strcpy(cName,cNidd);
printf("%d",iNo[0]);
printf("%s",cName);
}
```

Ans:

```
int iNo[3] = {10,20,30,40}; replace  this line by
int iNo[4] = {10,20,30,40};
The output will be
10
university
```

6. Explain following string manipulation functions.

`strncmp(), strlen(), strcat(), strstr(), strchar()`

Ans:

Name of function	Syntax	Meaning
strncmp	strncmp(s1,s2,n)	Compare first n characters of s1 and s2 and return result similar to strcmp
strlen	strlen(s)	Finds the length of string s.
strcat	strcat(s1,s2)	Concate string s2 at the end of string s1.
strstr	strstr(s1,s2)	Returns a pointer to the first occurrence of string s2 in s1
strchr	strchr(s,c)	Finds and returns the pointer to the first occurrence of character c in string s, otherwise returns NULL

: SHORT QUESTIONS :

1. **What is an array?**

⇒ Array is a collection of variables of same type known by a single name. The individual elements of an array are referred by their index value.

2. **Can we initialize an array in the program itself?**

⇒ Yes.

3. **Which function should be used to read a sentence having words, blank, tab etc?**

⇒ Function gets()should be used to read a sentence having words, blank, tab etc.

4. **Which built in functions reverses a string?**

⇒ Built in function strrev(s) reverse a string, s is the string to be reversed.

5. **Which built in function appends a string at the end of a string?**

⇒ Built in function strcat(s1,s2) appends a string at the end of a string, s2 string is concatenated at the end of string s1.

6. **Is it possible to have negative index in an array?**

⇒ Yes it is possible to index with negative value. It is illegal to refer to the elements that are out of array bounds, the compiler will not produce error because 'C' has no check on the bounds of an array.

7. **Why is it necessary to give the size of an array in an array declaration?**

⇒ When an array is declared, the compiler reserves enough space in memory for all the elements of the array. The size is required to allocate the required space and hence size must be mentioned.

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Module-6

Conditional Branching And Loops

Conditional Branching

- In the programs we have used sequence-' control structure in which the various steps are executed sequentially, i.e. in the same order in which they appear in the program. In fact to execute the instructions sequentially, we don't have to do anything at all. By default the instructions in a program are executed sequentially. However, in serious programming situations, seldom do we want the instructions to be executed sequentially. Many a times, we want a set of instructions to be executed in one situation, and an entirely different set of instructions to be executed in another situation. This kind of situation is dealt in C programs using a decision control instruction. As mentioned earlier, a decision control instruction can be implemented in C using:

Q.1. Write the decision control instruction implementing in C using. ?

Or Explain The if statement with example .?

Or Explain if-else statement with example ?

Or Explain The conditional operators with example ?

Ans. (a) The if statement

(b) The if-else statement

(c) The conditional operators

Now let us learn each of these and their variations in turn.

The if Statement

- Like most languages, C uses the keyword if to implement the decision control instruction. The general form of if statement looks like this:

```
if (this condition is true)
        execute this statement;
```

The keyword if tells the compiler that what follows, is a decision control instruction. The condition following the keyword if is always enclosed within a pair of parentheses. If the condition, whatever it is, is true, then the statement is executed. If the condition is not true then the statement is not executed; instead the program skips past it. But how do we express the condition itself in C ? And how do we evaluate its truth or falsity? As a general rule, we express a condition using C's 'relational' operators. The relational operators allow us to compare two values to see whether they

are equal to each other, unequal, or whether one is greater than the other. Here's how they look and how they are evaluated in C.

this expression	is true If
x == y	x is equal toy
X ! = y	x is not equal toy
x < y	x is less than y
x > y	x is greater than y
X < =	x is less than or equal to y
x > = y	x is greater than or equal to y

Figure

- The relational operators should be familiar to you except for the equality symbol == and the inequality symbol !=. Note that = is used for assignment, whereas, == is use for comparison of two quantities.

Example.

Write a simple program, which demonstrates the use of if and the relational operators.

Ans.

```
/* Demonstration of if statement */
main()
{
    int num;
    printf ( 'Enter a number less than 10");
    scanf ("%d", &num);

    if(num<=10)
        printf ( "What an obedient servant you are !");
}
```

- On execution of this program, if you type a number less than or equal to 10, you get a message on the screen through **printf( ).** If you type some other number the program doesn't do anything.

- To make you comfortable with the decision control instruction one more example has been given below. Study it carefully before reading further. To help you understand it easily, the program is accompanied by an appropriate flowchart.

Example.

While purchasing certain items, a discount of 10% is offered if the quantity purchased is more than 1000. If quantity and price per item are input through the keyboard, write a program to calculate the total expense

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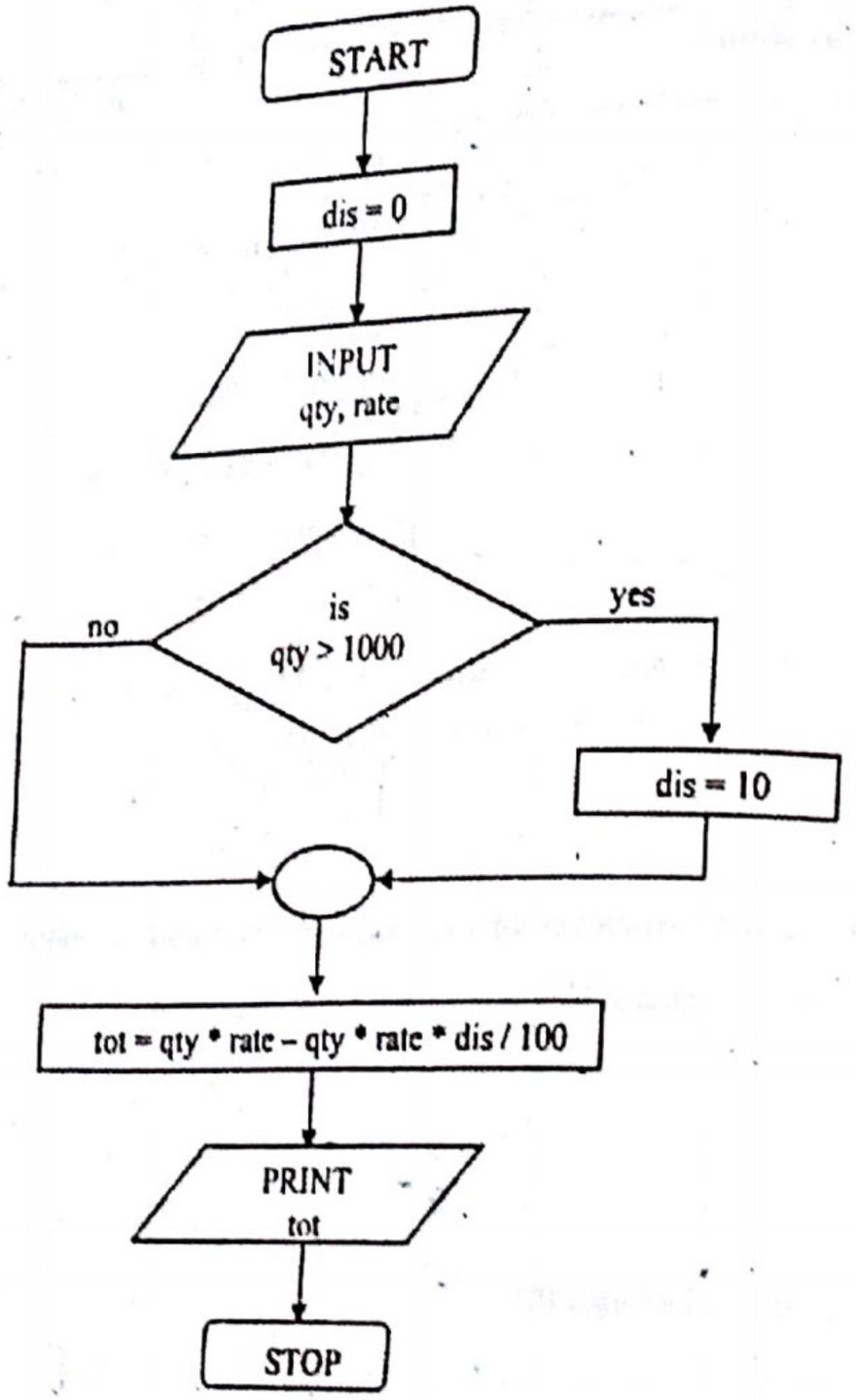
Ans.



Figure

```
/* Calculation of total expenses */
main( )
{
int qty, dis = 0;
float rate, tot;
printf ( "Enter quantity and rate");
scnf ( "%df", &qty, &rate);

if ( qty > 1000)
    dis = 10;
tot = (qty * rate) - (qty * rate * dis / 100);
printf ( "Total expenses = Rs. %, tot);
}
```


- Here is some sample interaction with the program.

  Enter quantity and rate 1200 15.50 Total expenses = Rs. 16740.000000

  Enter quantity and rate 200 15.50 Total expenses = Rs. 3100.000000

- In the first run of the program, the condition evaluates to true, since 1200 (value of qty) is greater than 1000. Therefore, the variable dis, which was earlier set to 0, now gets a new value 10. And using this new value total expenses are calculated and printed.

- In the second run the condition evaluates to false, since 200 (the value of qty) isn't greater than 1000. Thus, dis, which is earlier set to 0, remains 0, and hence the expression after the minus sign evaluates to zero, thereby offering no discount.

- Is the statement dis = 0 necessary? The answer is yes, since in C, a variable if not specifically initialized contains some unpredictable value (garbage value))

The if-else Statement

- The if statement by itself will execute a single statement, or a group of statements, when the condition following if is true. It does nothing when the condition is false. Can we execute one group of statements if the condition is true and another group of statements if the condition is false? Of course! This is what is the purpose of the else statement that is demonstrated in the following example:

Example :

In a company an employee is paid as under:

If his basic salary is less than Rs. 1500, then HRA = 10% of basic salary and DA = 90% of basic salary. If his salary is either equal to or above Rs. 1500, then HRA = Rs. 500 and DA = 98% of basic salary. If the employee's salary is input through the keyboard write a program to find his gross salary.

Ans.

```
/* Calculation of gross salary */
main()
{
    float bs, gs, da, hra;

    printf ( 'Enter basic salary')
    scanf ( '%f, &bs)

    if ( bs < 1500)
    {
        hra = bs * 10 / 100;
        da = bs * 90 / 100;
    }
```

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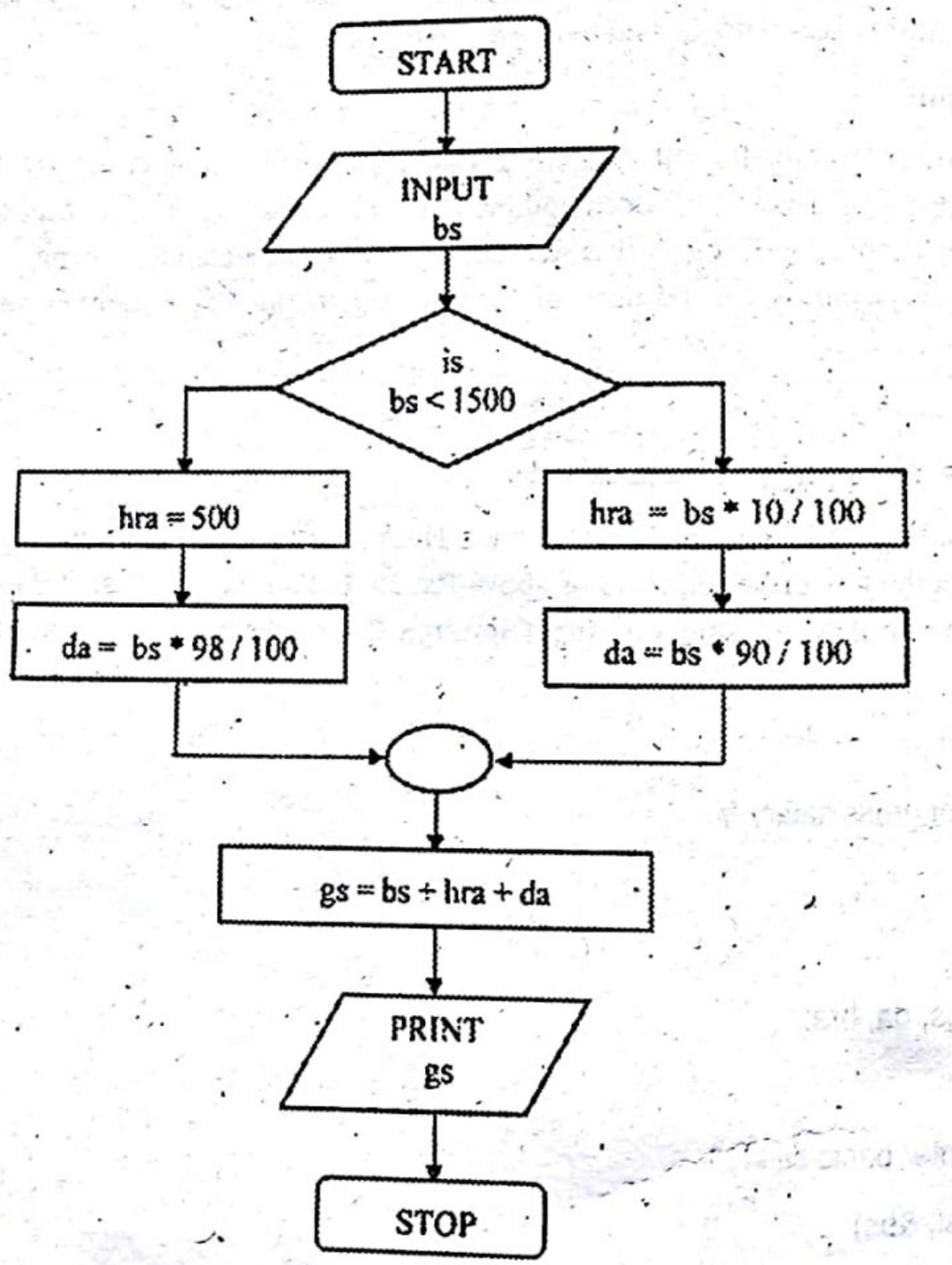
```
    else
    {
        hra 500;
        da = bs*98/ 100;
    }
    gs = bs + hra + da
    printf ( "gross salary = Rs. %f, gs);
}
```



Figure

A few points worth noting...

(a) The group of statements after the if upto and not including the else is called an 'if block'. Similarly, the statements after the else form the 'else block'.

(b) Notice that the else is written exactly below the if. The statements in the if block and those in the else block have been indented to the right. This formatting convention is followed throughout the book to enable you to understand the working of the program better.

(c) Had there been only one statement to be executed in the if block and only one statement in the else block we could have dropped the pair of braces.

(d) As with the if statement, the default scope of else is also the statement immediately after the else. To override this default scope a pair of braces as shown in the above example must be used.

Q.2. Explain Nested if elses .

Ans. Nested if-elses

It is perfectly all right if we write an entire if-else construct within either the body of the if statement or the body of an else statement. This is called nesting' of ifs. This is shown in the following program.

```
/* A quick demo of nested if-else */
main( )
{
    int i;

    printf ( "Enter either 1 or 2);
    scanf ("%d", &i);

    if (i.= = 1)
        printf ( "You would go to heaven !");
    else
    {
        if (i == 2)
            printf ( "Hell was created with you in mind")
        else
            printf ( 'How about mother earth !')
    }
}
```

Note that the second if-else construct is nested in the first else statement. If the condition in the first if statement is false, then the condition in the second if statement is checked. If it is false as well, the final else statement is executed.

You can see in the program how each time a structure is nested within another structure, it is also indented for clarity. Inculcate this habit of indentation; otherwise you would end up writing programs which nobody (you included) can understand easily at a later date.

In the above program an if-else occurs within the else block of the first if statement. Similarly, in some other program an if-else may occur in the if block as well. There is no limit on how deeply the ifs and the elses can be nested.

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Forms of if

The if statement can take any of the following forms:

```
(a) if ( condition)
        do this ;
(b) if ( condition)
    {
        do this ;
        and this ;
    }
(c) if ( condition)
        do this;
    else
        do this;
(d) if ( condition)
    {
        do this ;
        and this ;
    }
    else
    {
        do this ;
        and this ;
    }
(e) if ( condition)
        do this ;
    else
    {
        if ( condition)
            do this ;
        else
        {
            do this ;
            and this ;
```



```
            }
        }
(f) if ( condition)
    {
        if ( condition)
            do this ;
        else
        {
            do this ;
            and this ;
        }
    }
    else
        do this ;
```

The else if Clause

There is one more way in which we can write program for Example . This involves usage of else if blocks as shown

```
/* else if ladder demo */
main()
{
    int ml, m2, m3, m4, m5, per;

    per(m1 + m2 + m3 + m4 + m5)/per;

    if ( per >= 60
        printf ("First division")
    else if ( per >= 50)
        printf ("Second division");
    else if ( per >= 40  )
        printf ( "Third division")
    else
        printf ( "fail");
}
```

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- You can note that this program reduces the indentation of the statements. In this case every else is associated with its previous if. Even in else if ladder the last else is optional
- Another place where logical operators are useful is when we want to write programs for complicated logics that ultimately boil down to only two answers. For example, consider the following problem:

Example 1:

A company insures its drivers in the following cases :

- If the driver is married.
- If the driver is unmarried, male & above 30 years of age.
- If the driver is unmarried, female & above 25 years of age.

In all other cases the driver is not insured. If the marital status, sex and age of the driver are the inputs, write a program to determine whether the driver is to be insured or not.

We can write a program for the above problem in two ways:

(a) Without using && and 11 operators

(b) Using && and 11 operators

Method (a)

```
/* Insurance of driver - without using logical operators */
main()
{
    char sex, ms;
    int age;
    printf ( "Enter age, sex, marital status") ;
    scanf ( "%d %c %c", &age, &sex, &ms);

    if(ms == 'M')
        printf ( "Driver is insured") ;
    else
    {
        if ( sex == 'M')
        {
            if ( age > 30)
                printf ( "Driver is insured') ;
            else
                printf ( "Driver is not insured")
        }
```



```
        else
        {
            if ( age> 25)
                printf ( "Driver is insured");
            else
                printf ( "Driver is not insured")
        }
    }
}
```

Method (b)

- As mentioned above, in this example we expect the answer to be either 'Driver is insured' or 'Driver is not insured'. If we list down all those cases in which the driver is insured, then they would be:

(a) Driver is married.

(b) Driver is an unmarried male above 30 years of age.

(c) Driver is an unmarried female above 25 years of age.

- Since all these cases lead to the driver being insured, they can be combined together using && and || as shown in the program below:

```
/* Insurance of driver - using logical operators */
main( )
{
    char sex, ms ;
    int age;
    printf ( 'Enter age, sex, marital status');
    scanf ( "%d % %c" &age, &sex, &ms);

    if ( (ms = = 'M') || (ms = = 'U' && sex = = 'M' && age > 30) ||
                (ms = = 'U' && sex = = 'F' && age > 25))
        printf ("Driver is insured") ;
    else
        printf ("Driver is not insured") ;
}
```

In this program it is important to note that:

- The driver will be insured only if one of the conditions enclosed in parentheses evaluates to

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- For the second pair of parentheses to evaluate to true, each condition in the parentheses separated by && must evaluate to true.
- Even if one of the conditions in the second parentheses evaluates to false, then the whole of the second parentheses evaluates to false.
- The last two of the above arguments apply to third pair of parentheses as well.

- Thus we can conclude that the && and 11 are useful in the following programming situations:

(a) When it is to be tested whether a value falls within a particular range or not.

(b) When after testing several conditions the outcome is only one of the two answers.

There can be one more situation other than checking ranges or yes/no problem where you might find logical operators useful. The following program demonstrates it.

The Conditional Operators

- The conditional operators ? and : are sometimes called ternary operators since they take three arguments. In fact, they form a kind of foreshortened if-then-else. Their general form is,

expression 1 ? expression 2: expression 3

- What this expression says is: "if **expression 1** is true (that is, if its value is non-zero), then the value returned will be **expression 2,** otherwise the value returned will be **expression 3".** Let us understand this with the help of a few examples:

Examples :

(a)
```
int x, y ;
scanf("%d, &x);
y = (x > 5 ? 3 : 4);
```

This statement will store 3 in **y** if **x** is greater than 5, otherwise it will store 4 in y.

The equivalent if statement will be,

```
if (x > 5)
    y = 3;
else .
    y = 4;
```

(b)
```
char a;
int y;
scanf ( '%c' &a);
y = (a > = 65 && a < 90 ? 1 : 0);
```

The following points may be noted about the conditional operators:

(a) It's not necessary that the conditional operators should be used only in arithmetic statements. This is illustrated in the following examples:

Ex.:
```
int i ;
scanf ( '%d' &i);
```



```
(i = 1 ?printf("Amit") : pritf( "All and sundry"));
```

Ex.:
```
char a = 'z';
printf('%c' ,(a >= 'a' ? a : '!'));
```

(b) The conditional operators can be nested as shown below.

```
int big, a, b, c;
big = ( a > b ? ( a > c ? 3 : 4): (b > c ? 6 : 8));
```

(c) Check out the following conditional expression :

```
a > b ? g = a : g = b;
```

This will give you an error 'Lvalue Required'. The error can be overcome by enclosing the statement in the : part within a pair of parenthesis. This is shown below:

```
a > b ? g = a : (g = b);
```

In absence of parentheses the compiler believes that b is being assigned to an expression to the left of =. Hence it reports an error.

- The limitation of the conditional operators is that after the ? or after the only one C statement can occur. In practice rarely is this the requirement. Therefore, in serious C programming conditional operators aren't as frequently used as the if-else.

Exercise

if, if-else, Nested if-elses

[A] What will be the output of the following programs :

(a)
```
main( )
{
    int a = 300 b, c ;
    if ( a >= 400)
        b = 300;
        c = 200;
        printf( "\n%d%, b, c) ;
}
```

(b)
```
main( )
{
    int a = 500, b, c;

    if ( a >= 400 )
        b = 300 ;
        c = 200 ;
        printf( '\n%d %d", b, c).;
```

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```
    }
(c) main( )
    {
        int x = 10, y = 20;
        if(x == y);
            printf("\n%d%d",x, y) ;
    }
(d) main( )
    {
        int x = 3, y = 5;
        if(x == 3)
            printf("\n%d", x);
        else;
            printf ("\n%d", y) ;
    }
(e) main( )
    {
        intt x = 3 ;
        float y = 3.0 ;

        if ( x == y)
            printf ( "\nx and y are equal") ;
        else
            printf ("\nx and y are not equal' ) ;
    }
(f) main( )
    {
        int  x = 3, y, z ;
        y = x = 10;
        z = x < 10;
        printf("\nx =.%dy = %d z =%d",  x, y, z);
    }
(g) main( )
    {
        int k = 35 ;
```



```
        printf(\n%d %d %d", k == 35, k = 50, k > 40) ;
    }
```

[B] *Point out the errors, if any, in the following programs:*

```
(a) main()
    {
        float a = 12:25, b = 12.52 ;
        if (a = b)
            prinff ( "*\na and b are equal") ;
    }
(b) main( )
    {
        int j = 10, k = 12;
        if ( k >= j)
        {
            {
                k = j;
                j = k;
            }
        }
    }
(c) main( )
    {
        if ('X' < 'Y' )
        printf ( "\nascii value of X is smaller than that of x");
    }
(d) main( )
    {
        int x = 10;
        if ( x >= 2 ) then
            printf ( "\n%d", x);
    }
(e) main( )
    {
        int x = 10 ;
        if x >= 2
```

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```
        printf( \n%d, x);
    }
```

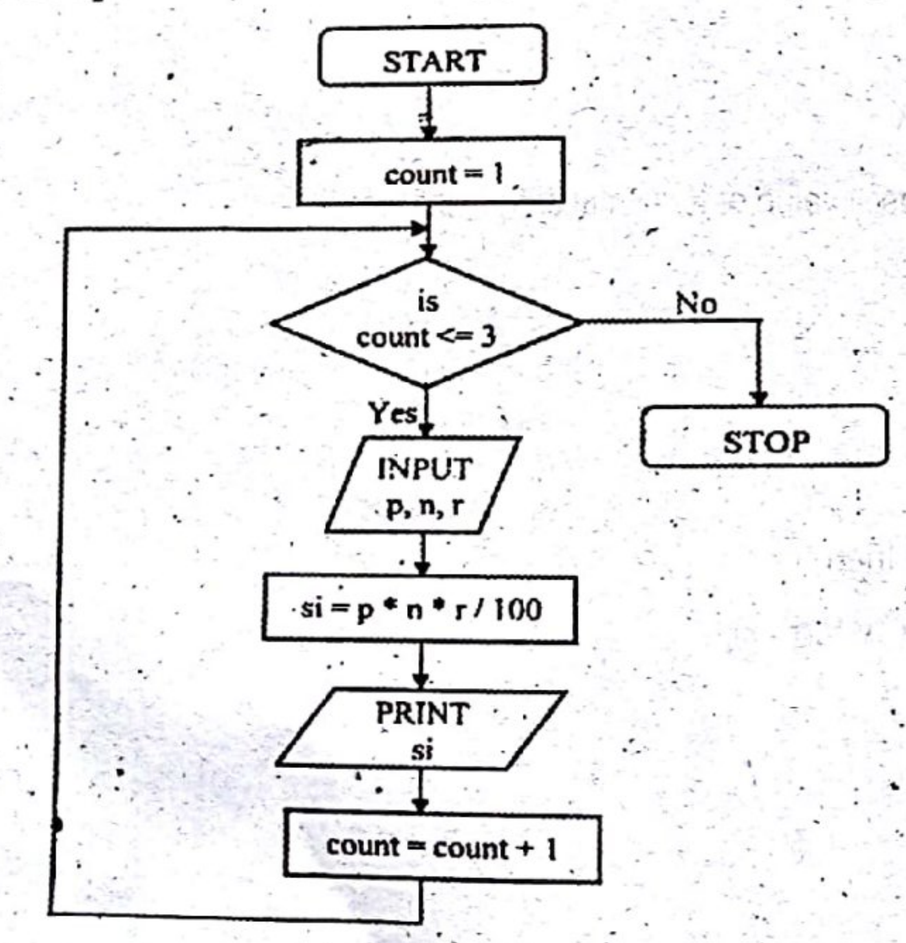
(f)
```
main( )
{
    int x 10, y = 15;
    if ( x % 2 = y % 3)
        printf ( "\nCarPathians) ;
}
```

Loops

- The versatility of the computer lies in its ability to perform a set of instructions repeatedly. This involves repeating some portion of the program either a specified number of times or until a particular condition is being satisfied. This repetitive operation is done through a loop control structure.
- There are three methods by way of which we can repeat a part of a program. They are:
  - (a) Using a for statement
  - (b) Using a while statement
  - (c) Using a do-while statement

The while Loop

- It is often the case in programming that you want to do something a fixed number of times. Perhaps you want to calculate gross salaries of ten different persons, or you want to convert temperatures from centigrade to fahrenheit for 15 different cities. The while loop is ideally suited for such cases. Let us look at a simple example, which uses a while loop. The flowchart shown below would help you to understand the operation of the while loop.



Figure


```
/* Calculation of simple interest for 3 sets of p, n and r */
main( )
{
    int p, n, count ;
    float r, si ;

    count = 1;
    while ( count <= 3)
    {
        printf ( "\nEnter values of p, n and r")
        scanf("%d %d %f", &p, &n, &r) ;
        si = p * n * r / 100;
        printf ("Simple interest = Rs %f", si);

        count = count + 1 ;
    }
}
```

And here are a few sample runs...

```
Enter values of p, n and r 1000 513.5
Simple interest = Rs. 675.000000
Enter values of p, n and r 2000 5 13.5
Simple interest = Rs. 1350.000000
Enter values of p, n and r 3500 5 3.5
Simple interest = Rs. 612.500000
```

The program executes all statements after the while 3 times. The logic for calculating the simple interest is written within a pair of braces immediately after the while keyword. These statements form what is called the 'body' of the while loop. The parentheses after the while contain a condition. So long as this condition remains true all statements within the body of the while loop keep getting executed repeatedly. To begin with the variable count is initialized to 1 and every time the simple interest logic is executed the value of count is incremented by one. The variable count is many a times called either a 'loop counter' or an 'index variable'.

Finally, what for are we using the '\n' in the printf( )? Just to ensure that every time after printing out the value of simple interest, the cursor should go to the next line, so that the message Enter values of p, n and r' appears on a new line. As seen in the first chapter '\n' is called 'newline' and is an escape sequence. The operation of the while loop is illustrated in the following figure.

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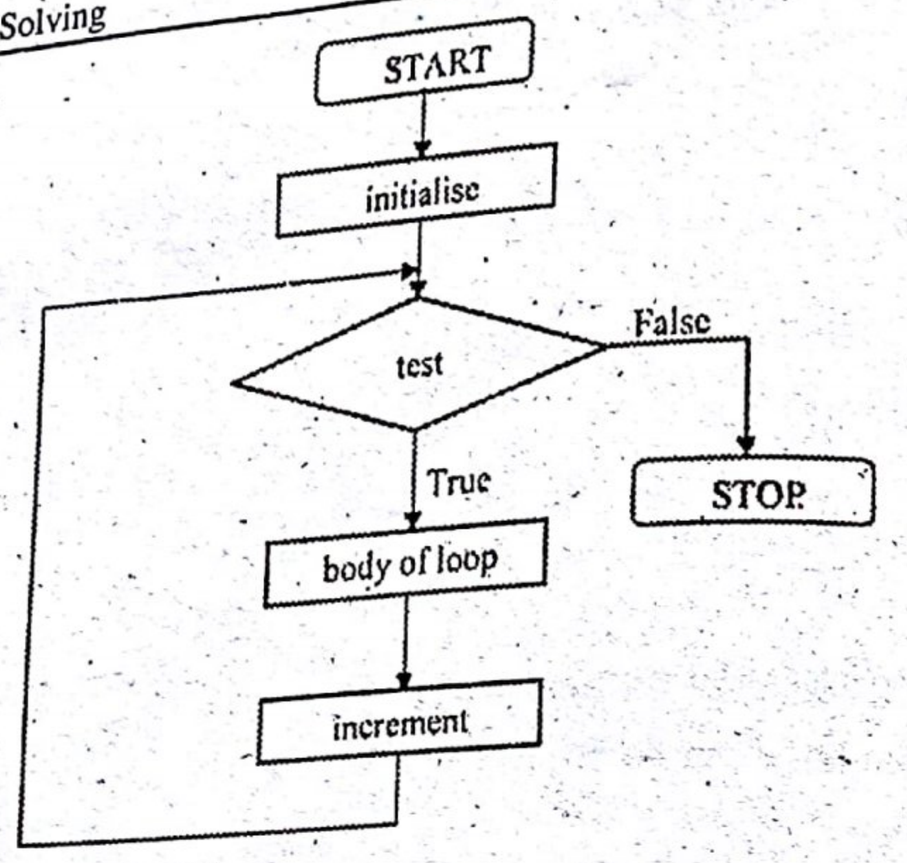

Figure

Tips and Traps

- The general form of while is as shown below:

```
initialise loop counter
while (test loop counter using a condition
{
    do this ;
    and this ;
    increment loop counter ;
}
```

- Note the following points about while...
  - The statements within the while loop would keep on getting executed till the condition being tested remains true. When the condition becomes false, the control passes to the first statement that follows the body of the while loop.
  - The condition being tested may use relational or logical operators as shown in the following examples:

```
while ( i <= 10)
while ( i >= 10 && j <= 15)
while (j > 10&& (b < 15 || c < 20))
```

  - The statements within the loop may be a single line or a block of statements. In the first case the parentheses are optional. For example,


```
while (i <= 10)
i = i + 1
```

is same as

```
while ( i <= 10)
{
    i = i + j;
}
```

As a rule the while must test a condition that will eventually become false, otherwise the loop would be executed forever, indefinitely.

```
main( )
{
    int i = 1 ;
    while (i <= 10)
        printf("%d\n", i) ;
}
```

This is an indefinite loop, since i remains equal to 1 forever. The correct form would be as under:

```
main( )
{
    int i = 1;
    while (i <= 10)
    {
        printf ("%d/n", i) ;
        i = i + 1 ;
    }
}
```

Instead of incrementing a loop counter, we can even decrement it and still manage to get the body of the loop executed repeatedly. This is shown below :

```
main( )
{
    int i = 5 ;
    while ( I >= 1)
    {
        printf ( "\nMake the computer literate!") ;
        i = i - 1 ;
```

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```
    }
}
```

- It is not necessary that a loop counter must only be an int. It can even be a **float.**

```
main( )
{
    float a = 10.0 ;
    while (a <= 10.5)
    {
        printf ( "\nRaindrops on roses...") ;
        printf ( "...and whiskers on kittens") ;
        a = a + 0.1
    }
}
```

- Even floating point loop counters can be decremented. Once again the increment and decrement could be by any value, not necessarily 1.
- What do you think will be the output of the following program?

```
main( )
{
    int i = 1;
    while ( i <= 32767)
    {
        printf ( "%d\n", i) ;
        i = i + 1 ;
    }
}
```

- No, it doesn't print numbers from 1 to 32767. It's an indefinite loop. To begin with, it prints out numbers from 1 to 32767. After that value of i is incremented by 1, therefore it tries to become – 32768, which falls outside the valid integer range, so it goes to other side and becomes –32768 which would certainly satisfy the condition in the while. This process goes on indefinitely.
- A word of caution! On a 32-bit Operating System like Windows or Linux an integer occupies 4 bytes instead of 2. Hence its range is – 2147483648 to + 2147483647. Thus the above loop would then print values up to 2147483647 before spilling over to the other side of the range.

What will be the output of the following program?

```
main( )
{
    int i = 1 ;
    while (i <= 10);
    {
        printf (" %d\n", i);
        i = i + 1
    }
}
```

This is another indefinite loop, and it doesn't give any output at all. The reason is, we have carelessly given a ; after the while. This would make the loop work like this...

```
while (i <= 10)
{

}
```

- Since the value of i is not getting incremented the control would keep rotating within the loop, eternally.

The for Loop

- Perhaps one reason why few programmers use while is that they are too busy using the for, which is probably the most popular looping control. The for allows us to specify three things about a loop in a single line:
  - (a) Setting a loop counter to an initial value.
  - (b) Testing the loop counter to determine whether its value has reached the number of repetitions desired.
  - (c) Increasing the value of loop counter each time the program segment within the loop has been executed.
- The general form of for statement is as under :

```
for (initialise counter; test counter increment counter)
{
    do this ;
    and this ;
    and this ;
}
```

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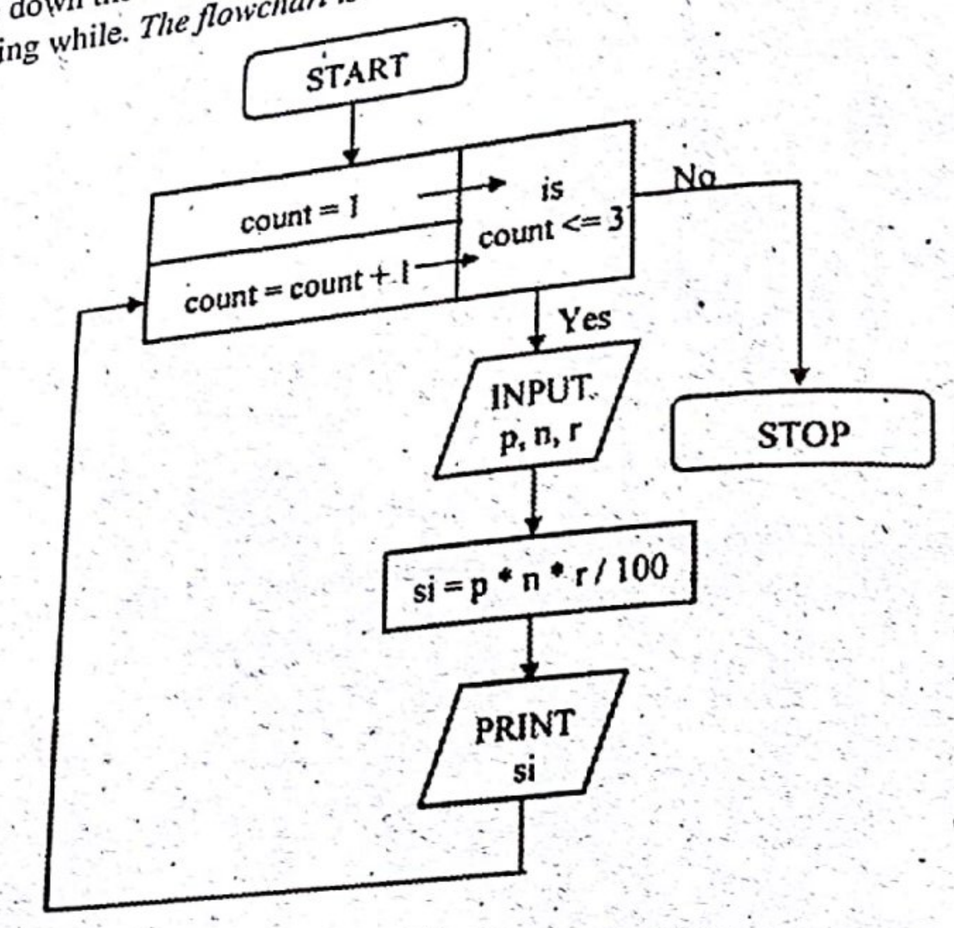
Let us write down the simple interest program using for. Compare this program with the one, which we wrote using while. *The flowchart is also given below for clarity.*



Figure

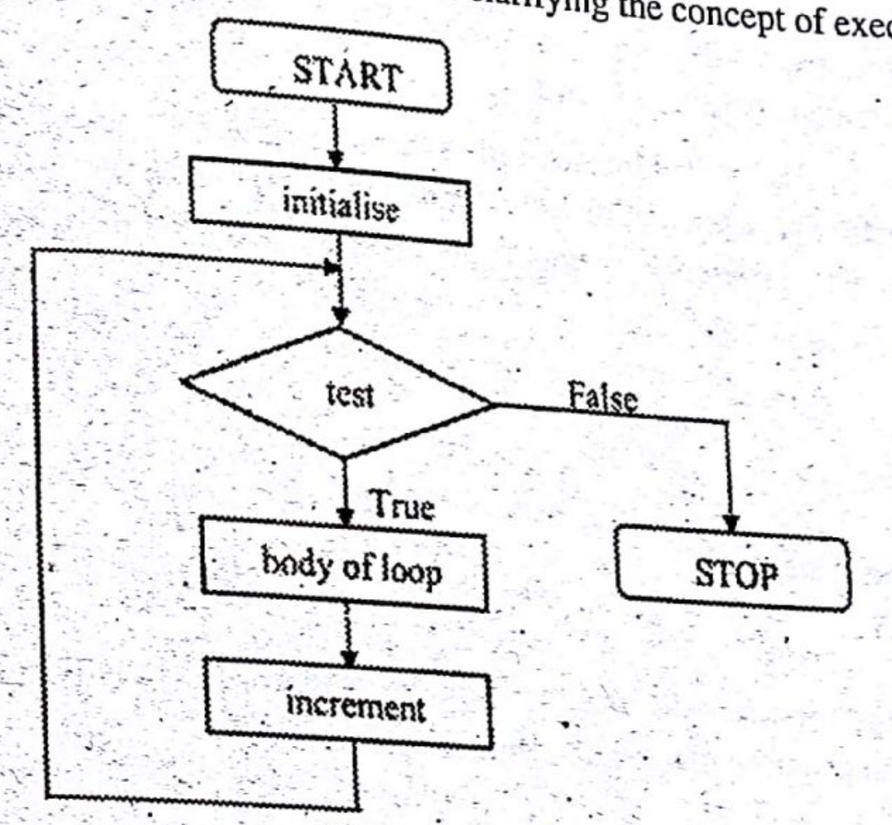
```
/* Calculation of simple interest for 3 sets of p, n and r */
main( )
{
    int p, n, count ;
    float r, si ;

    for ( count = 1; count <= 3 count = count + 1)
    {
        printf ( "Enter values of p, n, and r") ;
        scanf( "%d %d %f", &p, &n, &r);
    si = P * n *r/ 100 ;
    printf ( "Simple Interest = Rs.%f\n", si);
    }
}
```

- *If this program is compared with the one written using while, it can be seen that the three steps—initialisation, testing and incrementation—required for the loop construct have now been incorporated in the for statement.*

Let us now examine how the statement gets executed:

- When the statement is executed for the first time, the value of count is set to an initial value 1.
- "Now the condition count <= 3 is tested. Since count is 1 the condition is satisfied and the body of the loop is executed for the first time.
- Upon reaching the closing brace of for, computer sends the 8 control back to the for statement, where the value of count gets incremented by 1.
- Again the test is performed to check whether the new value of count exceeds 3.
- If the value of count is still within the range 1 to 3, the statements within the braces of for are executed again.
- The body of the for loop continues to get executed till count doesn't exceed the final value 3.
- When count reaches the value 4 the control exits from the loop and is transferred to the statement (if any) immediately after the body of for.
- The following figure would help in further clarifying the concept of execution of the for loop.



Figure

- Let us now write down the program to print numbers from 1 to 10 in different ways. This time we would use a for loop instead of a while loop.

(a)
```
main( )
{
    int i;
    for (i = 1 ; i <= 10 ; i = i + 1)
        printf ("%d\n", i) ;
}
```

Note that the initialisation, testing and incrementation of loop counter is done in the for statement itself. Instead of i = i + 1, the statements i++ or i += 1 can also be used.

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The do-while Loop

- The do-while loop looks like this :

```
do
{
    this ;
    and this ;
    and this ;
    and this ;
} while (this condition is true) ;
```

- There is a minor difference between the working of while and do-while loops. This difference is the place where the condition is tested. The while tests the condition before executing any of the statements within the while loop. As against this, the do-while tests the condition after having executed the statements within the loop.
- This means that do-while would execute its statements at least once, even if the condition fails for the first time itself. The while, on the other hand will not execute its statements if the condition fails for the first time. This difference is brought about more clearly by the following program.

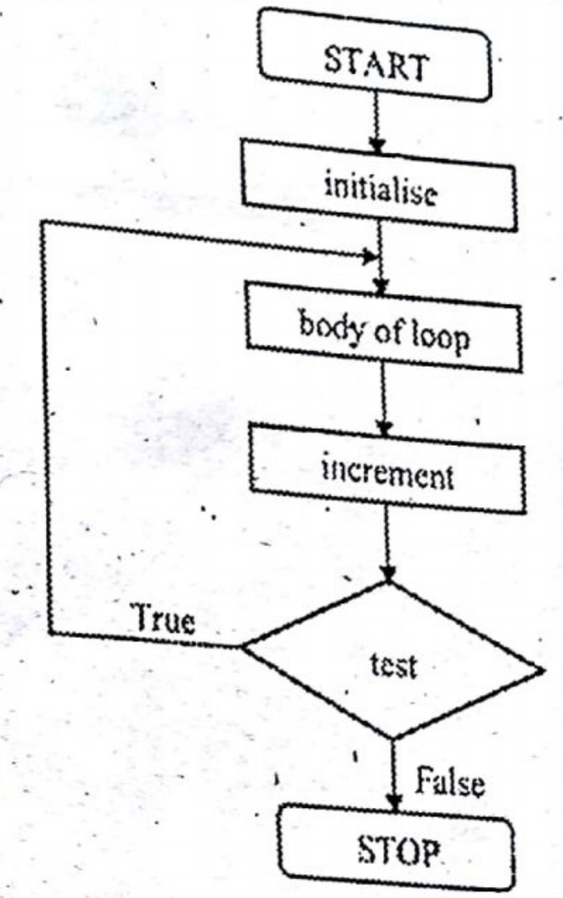
```
main( )
{
    while (4 < 1)
        printf ( "Hello there \n");
}
```

Here, since the condition fails for the first time itself the printf( ) will not get executed at all. Let's now write the same program using a do-while loop.

```
main( )
{
    do
    {
        printf ( "Hello there \n") ;
    } while (4 < 1);
}
```

- In this program the printf( ) would be executed once, since first the body of the loop is executed and then the condition is tested.
- Apart from this peculiarity of the do-while, the while and do-while behave exactly identically. do-while loops are rarely used in C programs, since there are comparatively fewer occasions when we want to execute a loop at least once no matter what.

- break and continue are used with do-while just as they would be in a while or a for loop. A break takes you out of the do-while bypassing the conditional test. A continue sends you straight to the test at the end of the loop; Figure would clarify the execution of do-while loop still further.



Figure

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Module-7

Basic Algorithms

Searching (Linear & binary)

Introduction

- Information retrieval is one of the most important applications of computers. Frequently, it becomes necessary to search a list of records to identify a particular record. Usually each record contains a field whose value is unique, to distinguish among the records, are known as keys. A particular record can be identified when the key value of that record is equal to a given input value. This operation is known as searching. If desired record is found then the search is said to be successful, otherwise it is unsuccessful. For instance, we way regard a telephone directory as a file, each record having three fields: name, address and phone number. The key is usually the person's name. However, one may wish to locate the record corresponding to a given number, in which case the phone number field would be the key.
- Searching for keys to locate records is often the most time consuming action in a program, and therefore the way the records are arranged and choice of method used for searching can make a substantial difference in program's performance. The searching problem falls into two cases. If there are many records, perhaps each one quite large, then it will be necessary to store the records in files on disk or tape, external to the primary memory. This case is called external searching. In the other case, the records to be searched are stored entirely in the primary memory. This case is called internal searching. In this chapter, we will consider only internal searching.

Types of Searching Techniques

Sequential Search

- The simplest way to do a search is to begin at one end of the list and scan down it until the desired key is found or the other end is reached. This search is applicable to a table organized either as an array or as a linked list. Let us assume that a is an array of n keys, a[0] through a[n-1]. Let us also assume that key is a search element. The process starts with a comparison between the first element (i.e. a[0]) and key. As long as a comparison does not result in a success, the algorithm proceeds to compare the next element of a and key. The process terminates when the list is exhausted or a comparison results in a success. This method of searching is also known as linear searching. In the following searching function the type of key field is considered to be integer.

Routine to search an item using sequential search

```
int Sequential Search (int a[ ], int n, int key)
{
    for (i = 0; i < n; i++)
```



```
    {
        if (key = = a[i])
            return (i);
    }
    return (-1) ;
}
```

- The function examines each key in turn; upon finding one that matches the search arguments its index is returned. If no match is found, -1 is returned. When the values of the array a are not distinct then the function will return the first index of the array a which is equal to key.

Analysis of sequential search

- The analysis of above searching function is based on the assumption that the array a contains distinct values. The number of comparisons for a successful search is not fixed. It depends on the position which key occupies within the array. If it is the first element then one comparison is necessary and if it is the last element then n comparisons are required. In general, i comparisons are necessary to search the ith element. Let P_i is the probability that i^{th} element will be searched, then the expected number of comparisons for a successful search is given by

$$C_s = 1.P_0 + 2.P_1 + \ldots + n.P_{n-1}$$

$$= \sum_{i=1}^{n} i.P_{i-1} \qquad \ldots(1)$$

Since P_i is the probability that record i is retrieved then

$$P_0 + P_1 + \ldots + P_{n-1} = 1$$

If it is assumed that any element is an equally likely candidate for searching then

$$P_0 = P_1 = \ldots = P_{n-1} = \frac{1}{n}$$

In this case, we have

$$C_s = \sum_{i=1}^{n} i.P_{i-1}$$

$$= \sum_{i=1}^{n} i.\frac{1}{n} \quad \left(\because P_{i-1} = \frac{1}{n}\right)$$

$$= \frac{1}{n}\sum_{i=1}^{n} i$$

$$= \frac{1}{n}(1 + 2 + \ldots + n)$$

$$= \frac{1}{n} \times \frac{n(n+1)}{2}$$

$$= \frac{(n+1)}{2}$$

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$$C_s = \frac{n+1}{2}$$

Therefore the expected number of comparisons in case of an unsuccessful search is given by

$$C_u = n$$

C_s is minimum when

$$P_0 \geq P_1 \geq P_2 \geq \ldots\ldots\ldots \geq P_{n-1}$$

In other words, C_s is very small when the most frequently searched elements are placed towards the beginning of the array.

Best case time complexity

The searched element is available at the first place i.e. at a[0]

$$T(n) = O(1)$$

Worst case time complexity

The searched element is available at the end of array i.e. at a[n – 1] or it is not available in the array.

$$T(n) = O(n)$$

Linear Search on a Sorted Array

- A reduction in the expected number of comparisons required for an unsuccessful search is possible when the linear search technique is applied to a sorted array. Assuming that the values appear in ascending order, the search can be terminated as soon as an element with a value greater than or equal to key is found. When the array element is equal to key then the search is successful.

Routine to search an item using sequential search in a sorted array

```
int Searchsequential Sorted (int a[ ], int n, int key)
{
    int i = 0;
    while ((key >= a[i]) && (i < n))
    {
        if (key = = a[i])
            return(I) ;
        i = i + 1 ;
    }
    return (-1)
}
```

- In this case, there is no change in the expected number of comparisons for a successful search. The number of comparisons required for an unsuccessful search depends on the given value of key. The number of comparisons for an unsuccessful search may be 1 in the best case and n + 1 in the worst case. In fact, this value may lie in any one of the (n +1) intervals created by then elements. If key lies in any one of these intervals with usual probability, the expected number of comparisons is given by

$$C_n = (1 + 2 + \ldots + n + n)/(n + 1)$$

Program:

Search for an element using sequential search

```
#include<stdio. h>
#include<conio. h>
int sequential search (int[ ], int, int) ;
void main( )
{
    int x[20], n, i, p, key ;
    clrscr( );
    printf("\nenter the number of elements:") ;
    scanf("%d" ,&n);
    printf("\nentcr %d elements\n",n) ;
    for (i=0; i<n; i++)
        scanf("%d" ,&x[i]) ;
    printf("\nenter the element to be searched:") ;
    scanf("%d", &key) ;
    p = sequential search (x, n, key) ;
    if (p== -1)
        printf("\nthe search is unsuccessful \n\n");
    else
        printf("\n %d is found at location %d", key, p);
}
int Sequential search (int a[ ], int n, int k)
{
    int i;
    for (i=0; i<n; i++)
    {
        if (k==a[i])
        return (i) ;
    }
    return (-1) ;
}
```

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Output

Run1

enter the number ofelements:6

enter 6 elements

15

35

25

65

55

45

enter the element to be searched:65

65 is found at location 3

Run2

enter the number ofelements:6

enter 6 elements

15

35

25

65

55

45 enter the element to be searched : 11

the search is unsuccessful

Explanation:

This program implements the concepts of searching an element linearly in a given array. The function Sequential Search() is used to search a given element in an array. If the searched element found in the array the function returns the index of the searched element in that array, otherwise returns -1.

Binary Search

- Sequential search is simple method for searching an element in an array. This is efficient for a small list of elements, but highly inefficient for larger lists. In the worst case, we will have to make n comparisons, as to search for the last element in the list.
- Binary search is a very efficient search technique which works for sorted lists. In this method, we make a comparison between key and the middle element of the array. Since the array is sorted, this comparison results either in a match between key and the middle element of array or identifying the left half or the right half of the array to which the desired element may belong. In the case, when the current element is not equal to the middle element of the array, the procedure is repeated on the half

in which the desired element is likely to be present, proceeding in this way, either the element is detected or the final division leads to a half consisting of no element.

There may be an ambiguity over the determination of the middle element of an array when the number of elements is even. In this case, there are two elements in the middle. However, an arbitrary choice of any one of these as the middle element will serve the purpose.

Routine to search an item using binary search

```
int     BinarySearch (int a[]    , int n, int key)
{
    int low, hi, mid;
    low = 0;
    hi = n-1;
while (low <= hi)
    {
        mid = (low + hi) / 2 ;
        if (key = = a[mid])
            return (mid) ;
        if (key < a[mid])
            hi = mid-1;
        else
            low  = mid + i;
    }
    return (-1)
}
```

Example 1:

Search the key value 33 in the following set of elements using binary search method.

11, 22, 33, 44, 55, 66, 77

11	22	33	44	55	66	77
0	1	2	3	4	5	6
↑ low			↑ mid			↑ hi

We wish to search for 33

So, key =33 low = 0 hi = 6 n=7

Is low ≤ h,, yes $mid = \frac{0+6}{2} = 3$

Is33 == a[3] no

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Since 33 < a[3], the steps will be repeated for the lower half i.e.

low = 0 and hi = mid- 1 i.e. hi = 2

low = 0 hi = 2

Is low ≤ hi, yes mid $= \frac{0+2}{2} = 1$

11	22	33	44	55	66	77
0	1	2	3	4	5	6
↑ low	↑ mid	↑ hi				

Is 33 == a[1] no

Since 33 > a[1], repeat the step with low = mid + 1 = 2 and hi = 2

low =2 hi = 2

Is low ≤ hi, yes mid $= \frac{2+2}{2} = 2$

11	22	33	44	55	66	77
0	1	2	3	4	5	6
		↑ mid = low = hi				

Is 33 == a[2] yes

The search is successful at index 2.

Analysis of Binary Search

- To analyze the performance of binary search, the maximum number of comparisons required for a successful search will be computed. Let i be the smallest integer such that

$$2^i \geq n+1 \quad \ldots(1)$$

- The maximum number of elements that are left after the first comparison is $2^i - 1$ and in general, the maximum number of elements left after k comparisons is $2^{i-1} - 1$. The desired element will definitely be found after i comparisons in which case we are left with no elements to be compared. Thus,

C_{max}, the maximum number of comparisons for a successful search is given by

$$C_{max} = i$$

So, From eqn (1) we can get,

$$2^i = n + 1$$

$$\Rightarrow \log_2 2^i = \log_2 (n+1)$$

$$\Rightarrow i\log_2 2 = \log_2 (n+1)$$

$$\Rightarrow i = \log_2 (n+1)$$

So, $C_{max} = \log_2 (n+1)$

Note that C_n, the number of comparisons required by an unsuccessful search, is equal to C_{max}. This is because, search can be declared as unsuccessful only when there are no elements to be probed.

Now, find the average number of comparisons under the assumption that each key is an equally likely candidate for a search. In other words, the probability that a particular element will be requested in a search is (1/n). For simplicity, we assume $n = 2^j - 1$ for some j. Now, the element in the middle position requires only one comparison to be searched. Similarly, the elements in the middle positions of the two halves require two comparisons each when searched. In this way we see that the total number of comparisons required to search every array clement is given by.

$$C = 1.2^0 + 2.21 + 3.22 + \ldots + j.2^{j-1} \quad \ldots(2)$$

To find an expression for C, multiply both sides of equation (2) by 2 to get

$$2.\ C = 1.2^1 + 2.2^2 + 3.2^3 + \ldots + j.2^j \quad \ldots(3)$$

Subtracting equation (2) from equation (3), we get

$$C = j.2^j - (2^0 + 2^1 + 2^2 + \ldots + 2^{j-1}) = j.2^j - \sum_{i=0}^{j-1} 2^i$$

$$= j.2^i - (2^j - 1) = j.2^j - 2^j + 1$$

$$= 1 + 2^j(j-1)$$

Now, C, the expected number of comparisons for a successful search, is given by

$$C_s = \frac{C}{n} = \frac{1 + 2^j.(j-1)}{n}$$

As we know $n = 2^j - 1 \Rightarrow 2^j = n + 1$

$$\Rightarrow j = \log_2 (n+2) \Rightarrow j - 1 = \log_2 (n+1) - 1$$

$$C_s = \frac{[1 + (n+1).\{\log_2 (n+1) - 1\}]}{n}$$

$$= \frac{(n+1).\log_2 (n+1)}{n}$$

$$= \log_2 n \text{ for large } n.$$

Although the above result has been derived under the assumption that n the number of elements, is of the form $2^j - 1$, the approximate result is also valid for any value of n. This is because there is no significant difference in the values of $\log_2 n$ for different values of n in the range $2^{j-1} \leq n \leq 2^j - 1$.

Thus, it is shown that the expected numbers of comparison for a successful as well as for an unsuccessful search are approximately given by

$$C_n = C_s = O(\log_2 n)$$

Best case time complexity

The searched element is available at the middle place i.e. at a[mid].

$$T(n) = O(1)$$

Worst case time complexity

$$T(n) = 0(\log_2 n)$$

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Program : Search for an element using Binary Search

```
#include<stdio.h>
#nd ude<coni o. h>
int Binary Search (int[], int, int);
void main( )
{
    int x[20], n, i, p, key;
    clrscr( );
    printf("\nenter the number of elements :");
    scanf("%d",&n);
    printf("\nenter %d elements in ascending order\n", n);
    for (i = 0; i<n; i++)
        scanf("%d" , &x [i]);
    printf("\nenter the element to be searched:");
    scanf("%d", &key);
    p = Binary Search(x, n, key);
    if (p == -1)
        printf("\nthe search is unsuccessful\n\n");
    else
        printf("\n %d is found at location %d", key, p);
  }
}
int BinarySearch(int a[ ], int n, int k)
{
    int lo, hi, mid;
    lo = 0;
    hi = n-1;
    while (1o <= hi)
    {
        mid = (1o+hi)/2 ;
        if (k==a[mid])
        return (mid) ;
        if (k < a[mid])
```



```
            hi = mid -1;
            else
        1o = mid + 1;
    }
    return (-1);
}
```

Output

Run 1

enter the number of elements : 6

enter 6 elements in ascending order

11

22

33

44

55

66

enter the element to be searched : 55

55 is found at location 4

Run 2

enter the number of elements:6

enter 6 elements in ascending order

11

22

33

44

55

66

enter the element to be searched:34

the search is unsuccessful

Explanation:

This program implements the concepts of binary search algorithm. The precondition for this program is that the elements in the array must be in sorted order. This program is implemented by considering the elements of the array are in ascending order. The function BinarySearch() is used to find the position of a given element in an array. If the searched element is found in the array the function returns the index of the searched element in that array, otherwise returns -1.

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Sorting

- Retrieval of information is made easier when it is stored in some predefined order. Sorting is, therefore, a very important computer application activity. Many sorting algorithms are available. Use of different sorting methods differ depending on their applications. Sorting algorithms can be characterized in the following two ways:

  i) Simple algorithms which require the order of n- (written as 0(n2)) comparisons to sort n elements.

  ii) Sophisticated algorithms that require the 0(n log,n) comparisons to sort n elements.

- The difference lies in the fact that the first method moves data only over small distances in the process of sorting, whereas the second method moves data over large distances, so that items settle in to the proper order sooner, thus resulting in fewer comparisons. Performance of a sorting algorithm can also depend on the degree of order already present in the data.

- There are two basic categories of sorting methods: Internal Sorting and External Sorting. Internal sorting applied when the entire collection of data to be sorted is small enough that the sorting can take place within main memory. The time required to read or write is not considered to be significant in evaluating the performance of internal sorting methods. External sorting methods are applied to larger collection of data which reside on secondary devices, read and write access time are major concern in determining sort performances.

- In this section, we will discuss some methods of internal sorting.

- Sorting is formally defined on list of elements $a_1, a_2, \ldots a_n$, where a binary relation $\leq$ is defined for any two distinct elements, a_i and a_j, for that list.

  Input : A sequence of n numbers $<a_1, a_2, \ldots d_2>$

  Output : A permutation (reordering) $<a'_1, a'_2, \ldots a'_n>$ of the input sequence such that $a'_1 \leq a'_2 \leq \ldots \leq a'_n$

  The input sequence is usually. n-element array.

Bubble Sort

- A well known algorithm called bubble sort proceeds by scanning the list from left to right, and whenever a pair of adjacent keys found out of order, then those items are swapped. This process repeats till all the elements of the list are in sorted order.

- Let a is an array of n integers in which the elements are to be sorted, so that $a[i] \leq a[j]$ for $0 \leq i < j < n$. The basic idea of bubble sort is to pass through the list sequentially several times. Each pass consists of comparing each element in the list with its successors and interchanging the two elements if they are not in the proper order.

- The bubble sort algorithm works as follows:

Pass 1: Compare a[0] and a [1] and arrange them in the desired order so that $a[0] \leq a[1]$. Then compare a[1] and a [2] and arrange them so that $a[1] \leq a[2]$. Continue until we compare a[n-2] and a[n-1] and arrange them so that $a[n-2] \leq a[n-1]$. This step involves n-1 comparisons. During this process, the largest element is bubbled up to the $(n-1)^{th}$ position.

Pass 2: Repeat the above process with one less comparison i.e., we stop after we compare and possibly rearrange a[n-3] and a[n-2]. This involves n-2 comparisons when the entire process is completed, the second largest element will occupy a[n-2].

Pass n-1: Compare a[0] and a[1] and arrange them so that $a[0] \leq a[1]$.

After n-1 steps, the list will be arranged in non decreasing order.

Example 2: Arrange the following list of elements in sorted order using bubble sort

44, 55, 33, 88, 77, 22, 11, 66

Suppose the following numbers are stored in an array a:

44	55	33	88	77	22	11	66
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

We apply the bubble sort to the array a. Let us discuss each pass separately.

Pass 1 We have the following comparisons.

a) Compare a[0] and a [1]. Since 44 < 55, the list is not altered.

b) Compare a[1] and a [2]. Since 55 > 33, interchange 55 and 33 as follows:

44	33	55	88	77	22	11	66
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

c) Compare a[2] and a[3]. Since 55 < 88, the list is not altered.

d) Compare a[3] and a[4]. Since 88 > 77, interchange 88 and 77 as follows :

44	33	55	77	88	22	11	66
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

e) Compare a[4] and a[5]. Since 88 > 22, interchange 88 and 22 as follows:

44	33	55	77	22	88	11	66
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

f) Compare a [5] and a [6]. Since 88 > 11, interchange 88 and 11 as follows:

44	33	55	77	22	11	88	66
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

g) Compare a[6] and a[71. Since 88 > 66, interchange 88 and 66 as follows :

44	33	55	77	22	11	66	88
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]

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At the end of this first pass, the largest number, 88 has moved to the last position. However, the rest of the numbers are not sorted, even though some of them have changed their positions.

For the remainder of the passes, we show only the interchanges by using circles.

Pass 2

33	44	55	77	22	11	66	88
33	44	55	22	77	11	66	88
33	44	55	22	11	77	66	88
33	44	55	22	11	66	77	88

At the end of pass 2, the second largest number, 77 has moved its way down to the next to last position.

Pass 3

33	44	22	55	11	66	77	88
33	44	22	11	55	66	77	88

Pass 4

33	22	44	11	55	66	77	88
33	22	11	44	55	66	77	88

Pass 5

22	33	11	44	55	66	77	88
22	11	33	44	55	66	77	88

Pass 6

11	22	33	44	55	66	77	88

Pass 6 actually has two comparisons, a[0] with a[1] and a[1] with a[2]. The second comparison does not involve an interchange.

Pass 7

Finally a[0] is compared with a[1]. Since 11 < 22, no interchange taken place.

Since the list has 8 elements; it is sorted after the seventh pass. In this example, the list was sorted after the sixth pass.

Program 1 Arrange the list of umbers in ascending order using Bubble Sort

```
#include<stdio.h>
#include<conio.h>
void BubbleSort(int[ ], int) ;
void main( )
{
```



```
    int x[20],n, i;
    clrscr( ) ;
    printf("\nenter the number of numbers to be sorted:") ;
    scanf("%d", &n) ;
    printf("\nenter %d elements\n", n) ;
    for (i = 0 ; i<n ; i++)
        scanf("%d",&x[i]);
    BubbleSort (x, n) ;
    printf("\nthe sorted array is\n\n") ;
    for (i=0; i<n ; i++)
        printf("%4d", x[i]) ;
}
void BubbleSort(int a[], int n)
{
    int temp, pass, i ;
        for (pass=0; pas s<n-1; pass++)
        {
            for (i=0; i<n-pass-1; i++)
            {
                temp=a[i] ;
                a[i] = a[i+1]) ;
                a[i+1]=temp ;
            }
        }
    }
}
```

Output

```
enter number of numbers to be sorted:6
enter 6 elements
the sorted array is
66
33
44
```

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55

77

11

11 33 44 55 66 77

Explanation :

This program is used to arrange a given array of elements in ascending order using bubble sort. In BubbleSorr() function, an array of size n requires (n-1)passes and n-pass-1 comparisons in each pass, where the outer loop is used for number of passes and the inner loop is used for number of comparisons in each pass.

Insertion Sort

- Insertion sort is an efficient algorithm for sorting a small number of elements. It sorts a set of 'values by inserting values in to an existing sorted File. This method can be explained in the similar way the arrangement of cards by a card player. The card player picks up the cards and inserts them in to the required position. Thus at every step, we insert an item in to its proper place in an already ordered list.
- Suppose an array a with n elements a[0], a [1].....a[n-1] is in memory. The insertion sort algorithm scans a from a[0] to a[n-1], inserting each element a[k] in to its proper position in the previously sorted subarray a[0], a[1].....a[k-1]. That is :

Pass 1a[0] by itself is trivially sorted.

Pass 2a[1] is inserted either before or after a[0] so that : a[0], a[l] are sorted.

Pass 3a[2] is inserted in to its proper place in a[0], a[1], that is, before a[0], between a[0] and a[1], or after a[1], so that : a[0], a[1], a[2] are sorted.

Pass4 a[3] is inserted into its proper place in a[0], a[1], a[2] so that: a[0], a[1], a[2], a[3] are sorted.

Pass na[n-1] is inserted in to its proper place in a[0], a[l],....,a[n-2] so that : a[0], a[1], ...a[n-1] are sorted.

Example 3 : Arrange the following elements in the sorted order using insertion sort.

30,20,35,14,90,25,32

Store all elements in an array a of elements

30	20	35	14	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 1 a[l] < a[0], interchanging the position of the elements, we get

20	30	35	14	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 2 a[2] > a[1], position of the elements remain same.

20	30	35	14	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 3 a[3]is less than a[0], a[1] and a[2], so insert

14	20	30	35	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 4 a[4] > a[3] position of the elements remain same

14	20	30	35	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 5 a[5] is less than a[2], a[3] and a[4], therefore insert a [5] before a[2], we get

14	20	25	30	35	90	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 6a[6] is less than a[4], a[5] therefore insert a [6] before a[4], we get

14	20	25	30	32	35	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

After pass 6, we get the array in sorted order.

Program 11.4 Arrange the list of numbers in ascending order using Insertion Sort

```
#include<std : o . h>
#include<con ; o . h>
void Insertionsort (int[ ], int) ;
void main( )
{
    int x[20], n, i ;
    clrscr( );
    printf("\nenter the number of numbers to be sorted:") ;
    scanf("%d", &n) ;
    printf("\nenter %d elements\n", n) ;
    for (i=0; i<n; i++)
        scanf("%d ,&x[i]) ;
    InsertionSort(x, n) ;
    printf("\nthe sorted array is\n\n") ;
```

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```
    for (i=0; i<n ; i++)
        printf("%4d", [i]) ;
}
void Insertionsort(int a[ ], int n)
{
    int i, j, key;
    for (j=1; j<n; j++)
    {
        key=a[j] ;
        i=j-1 ;
        while((i >-1)&&(a[i]>key))
        {
            a[i+1]=a[i];
            i = i -1;
        }
        a[i+1] =key;
    }
}
}
```

Output

enter the number of numbers to be sorted:6

enter 6 elements

33

22

88

66

99

11

the sorted array is

11 22 33 66 88 99

Explanation :

This program is used to arrange a given array of elements in ascending order using insertion sort. The insertion sort is highly efficient if the array is already in almost sorted order. In InsertionSort() function, the outer most loop is used to choose an element from the array, whereas the inner loop is used to place the chosen element in its appropriate position within the elements preceade to it.

Selection Sort

The selection sort is also known as pushdown sort. This sort consists entirely of a selection phase in which the largest of the remaining elements, large, is repeatedly placed in its proper position.

Let a be an array of n elements.

Pass 1 Find the position i of the largest element in the list of n elements a[0], a[1].....,a[n-1] and then interchange a[i] with a[n- 1]. Then a[n-1] is sorted.

Pass 2 Find the position i of the largest in the sublist of n-1 elements a[0], a[1].....a[n-2]. Then interchange a[i] with a[n-2]. Then a[n-2], a[n- 1] are sorted.

Pass 3 Find the position i of the largest element in the sublist of n-2 elements a [0], a[1].....a[n-3]. Then inrerchange a[i] with a[n-3]. Then a[n-3], a[n-2], a[n-1] are sorted..

Pass n-1 Find the position i of the largest of the elements a[0], a[1] and then interchange a[i] with a[1]. Then a[0], a[1].....a[n-1] is sorted.

Example 5: Arrange the following elements in sorted order using selection sort.

30, 20, 35, 14, 90, 25, 32

Store all the elements in an array a of elements

Pass 1 90 is the largest element in between a[0} and a[6] and its position is 4. Hence by exchanging a[4] with a[6] the array becomes:

30	20	35	14	90	25	32
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 2 35 is the largest element in between a[0] and a[5] and its position is 2. Hence by exchanging a [2] with a [5] the array becomes:

30	20	35	14	32	25	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 3 32 is the largest element in between a[0] and a[4] and its position is 4. No exchanagc is required. Hence the array becomes:

30	20	25	14	32	35	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 4 30 is the largest element in between a[0] and a[3] and its position is 0. Hence by exchanging a[0] with a[3] the array becomes:

14	20	25	30	32	35	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

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Pass 5 25 is the largest element in between a[0] and 42] and its position is 2. No exchange is required. Hence the array becomes:

14	20	25	30	32	35	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

Pass 6 20 is the largest element in between a[0] and a[1] and its position is 1. No exchange is required. Hence the array becomes:

14	20	25	30	32	35	90
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]

After Pass get the array in sorted order.

Program 2. Arrange the list of numbers in ascending order using Selection Sort

```
#include<stdio.h>
#include<conio.h>
void Selectionsort(int[ ], int);
void main( )
{
    int x [20], n, i ;
    clrscr( ) ;
    printf("\nenter the number of numbers to be sorted:");
    scanf("%d", &n);
    printf("\nenter %d elements\n", n);
    for  (i = 0; i < n ; i++)
        scanf(%d", &x[i]);
    selectionsort(x, n);
    printf("\nthe sorted array is\n\n");
    for (i = 0; i < n; i++)
        printf("%4d", x [i]) ;
  }
void seiectionsort(int a[], mt n)
{
    int i, pos, j, iarge;
    for (i=n-1; i>0;i--)
    {
```



```
        large=a[0];
        pos=0;
        for (j=1; j<=i; j++)
        {
            if (a[j]>iarge)
            {
                large=a[j] ;
                pos=j ;
            }
        }
        a[pos]=a[i] ;
        a[i ]=i arge ;
    }
}
```

Output

```
enter the number of numbers to be sorted:6
enter 6 elements
30
20
80
90
10
the sorted array is
10 20 30 60 80 90
```

Explanation : This program is used to arrange a given array of elements in ascending order using selection sort. In SelectionSort( ) function, the outer most loop is used to get the position of the elements in the array starting from last index down to 1 and in each iteration of the outer loop the inner loop is used to find position of the largest value among the elements from 0th position till the current index selected in the outer loop. Before starting next iteration of the outer loop the values between the index of the outer loop and the position found by the inner loop are exchanged.

Example 1 :

Order of complexity Example :

Routine to arrange the list elements in ascending order using bubble sort .

```
void Bubblesort(int a[ ], int n)
{
```

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```
    int temp, pass, i;
    for (pass=0; pass < n-1; pass++)
    {
        for (i = 0; I < n=pass-1; 1++)
        {
            if (a[i] > a[i +1])
            {
                temp = a[i] ;
                a[i]=a[i+1] ;
                a[i +1] =temp ;
            }
        }
    }
}
```

Complexity of the Bubble Sort Algorithm

- There are (n-1)comparisons during the first pass which places the largest element in the last position. There are (n-2) comparisons in the second pass which places the second largest element in the next to last position and so on. Thus,

$$T(n) = (n) + (n-2) + \ldots + 2 + 1$$

$$= \frac{n(n-1)}{2} = \frac{n^2}{2} - \frac{n}{2} = O(n^2)$$

Example 2 :

Routine to arrange the list of elements in ascending order using insertion sort

```
1   void InsertionSort(int a[], int n)
2   {
3       int  i, j, key ;
4       for (j=1 ;j<n; j++)
5       {
6           key=a[j] ;
7           i=j-1;
8           while((i>-1)&&(a[i]>key))
9           {
10              a[i+1]=a[i] ;
11              i=i-1 ;
```



```
12          }
13          a[i+1]=key ;
14      }
15  }
```

Line no.	Cost	Times
4	c_1	n
6	c_2	n-1
7	c_3	n-1
8	c_4	$\sum_{j=1}^{n-1} t_j$
10	c_5	$\sum_{j=1}^{n-1} t_{j-1}$
11	c_6	$\sum_{j=1}^{n-1} t_{j-1}$
13	c_7	n-1

$$T(n) = c_1 n + c_2(n-1) + c_3(n-1) + c_4 \sum_{j=1}^{n-1} t_j + c_5 \sum_{j=1}^{n-1} (t_j - 1) + c_6 \sum_{j=1}^{n-1} (t_j - 1) + c_7 (n-1)$$

where t_1 is the number of times the while loop test in line 8 is executed for that value of j.

Best case time complexity

Best case occurs when the array is already in sorted form. In this case, the control will not enter in to the while loop in line 8. So $t_j = 1$ for each j.

$$T(n) = c_1 n + c_2, (n-l) + c_3(n-1) + c_4 (n-l) + 0 + 0 + c_7 (n-1)$$

$$= an + b \text{ where a and b are constants.}$$

So, $T(n) = O(n)$

Worst case time complexity

Worst case occurs when the array is in reverse order. In this case, the number of times the statements inside the while loop will be executed depends upon the value of j.

So, $t_j = j + 1$

i.e., $$\sum_{j=1}^{n-1} t_i = 2 + 3 + \ldots + n = \frac{n(n+1)}{2}$$

$$\sum_{j=1}^{n-1} (t_j - 1) = 1 + 2 + \ldots + n - 1 = \frac{(n-1)\,n}{2}$$

$$T(n) = an^2 + bn + c$$

where t, b and c are constants.

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So, $T(n) = O(n^2)$

Example 3 :

Routine to arrange the list of elements in ascending order using selection sort

```
void Selectionsort(int a[ ], int n)
{
    int i, pos, j, large ;
    for (i=n-1 ; i>0; i--)
    {
        large=a[0];
        pos=0;
        for (j=1; j<=m ; j++)
        {
            if (a[j]>large)
            {
                large=a[j] ;
                pos=j
            }
        }
        a[pos]=a[i];
        a[i]=large;
    }
}
```

Time complexity of selection sort algorithm

- Analysis of selection sort is straight forward. The first pass makes n-1 comparisons, the second pass makes n-2 comparisons and so on. Therefore there is total of

$$(n-1) + (n-2) + (n-3) + \ldots +1$$

$$= n(n-1)/2 \text{ comparisons.}$$

So, $T(n) = Q(n^2)$

Example 4 :

Routine to arrange the list of elements in ascending order using quick sort -Quick Sort

```
Void Quicksort(int a[ ], int p, int r)
{
    int q ;
```



```
    if (p < r)
    {
        q = Partition(a, p, r) ;
        QuickSort(a, p, q) ;
        QuickSort(a, q+1, r) ;
    }
}
```

Partitioning the array

The key to the algorithm is the Partition() function, which rearranges the subarray a[p]...a[r]in place.

Routine to partition the array for quick sort

```
int Partition(int a[], int p, int r)
{
    int x, i, j, temp ;
    x = a[p] ;
    i = p - 1;
    j = r +1;
    while (1)
    {
        do
        {
            j=j-1 ;
        } while (a[j]>x) ;
        do
        {
            i=i+1 ;
        } while (a[i]<x) ;
        if (i<j)
        {
            temp=a[i] ;
            a[i ]=a[j] ;
            a[j]=temp ;
        }
        else
```

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```
        return (j) ;
    }
}
```

How partition works

- It first selects an element x = a[p] from a[p] ...a[r] as a pivot element around which to partition a[p] ...a [r]. It then grows two regions a[p]...a[i] and a[j]...a[r] from the top and bottom of a[p]...a[r] respectively, such that every element in a[p]...a[i] is less than or equal to x and every element in a[j]...a[r] is greater than or equal to x. Initially, i = p-1 and j = r+ 1, so the two regions are empty.
- Within the body of the while loop, the index j is decremented and the-index i is incremented, until a[i] ≥ x ~! a[j]. Then a[i] and a[j] are interchanged. The body of the while loop repeats until i ≥ j, at which point the entire array a [p...a[r] has been partitioned in to two sub arrays a[p]... a[q] and a[q + 1]... a[r], where p ≤ q < r, such that no element of a[p]... a[q] is larger than any element of a [q+1]...a[r]. The value q = j is returned at the end of the function.

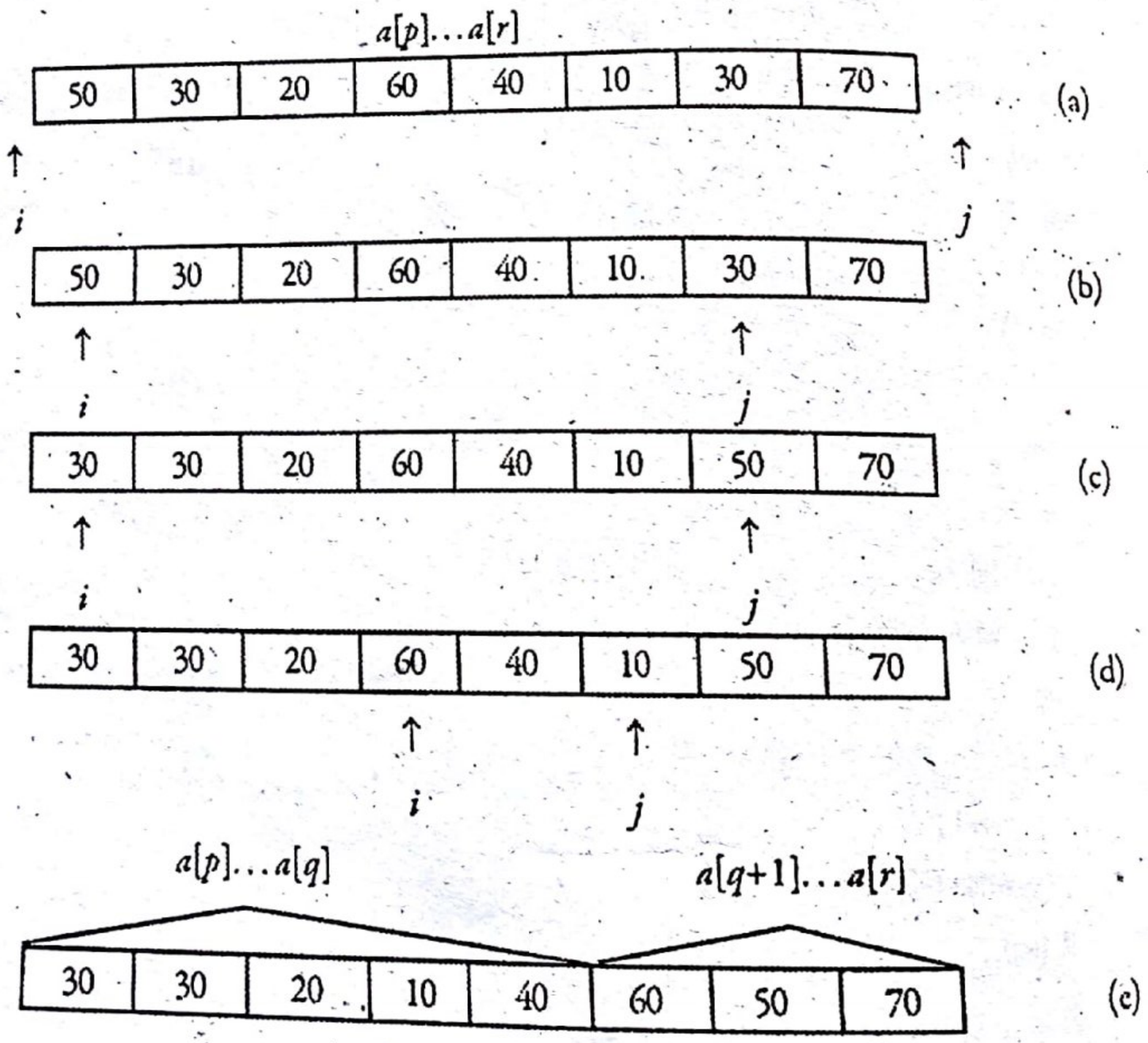

Figure 1 Step by step method of partitioning an array.

- Figure 1 (a) shows an input array, with the initial values of i and j just off the left and right ends respectively. We partition the array around x = a[p] = 50. Figure 1 (b) shows the positions of i and j after the first iteration of the while loop. Figure 1 (c) shows the result of exchanging the elements pointed by i and j. Figure 1 (d) shows the positions of i and j after the second iteration of the while loop. Figure 1 (e) shows the positions of i and j of the third and last iteration of the while loop. The

procedure terminates because i ≥ j, and the value q = j is returned. Array elements up to and including a[j] are less than or equal to x = 50 and array elements after a [j] are greater than or equal to x = 50.

Performance of quick sort

- The running time of quick sort depends on whether the partitioning is balanced or unbalanced, and this in turn depends on which elements are used for partitioning. If the partitioning is balanced (i.e. the array is divided into two equal halves), the algorithm runs asymptotically as fast as merge sort. If the partitioning is unbalanced, however, it can run asymptotically as slow as insertion sort.

Worst case partitioning

- The worst case behaviour for quick sort occurs when the partitioning function produces one region with n-I elements and the other with only 1 element. Let us assume that this unbalanced partitioning arises at every step of the algorithm. Since partitioning costs θ (n) time and T(1) = θ(1), the recurrence of the running time is

$$T(n) = T(n-1) + \theta(n)$$

To evaluate this recurrence, we observe that T(l) = θ(1) and then iterate:

$$T(n) = T(n-1) + \theta(n)$$

$$T(n) = T(n-2) + \theta(n-l) + \theta(n)$$

$$= T(n-3) + \theta(n-2) + \theta(n-1) + \theta(n)$$

$$= T(n-4) + \theta(n-3) + \theta(n-2) + \theta(n-1) + \theta(n)$$

$$= T(l) + \theta(2) + \theta(3) + \ldots + \theta(n)$$

$$= \theta(1) + \theta(2) + \theta(3) + \ldots + \theta(n)$$

$$= \sum_{k=1}^{n} \theta(k)$$

$$= \theta \sum_{k=1}^{n} k$$

$$= \theta(n^2)$$

- If the partitioning is maximally unbalanced at every recursive step of the algorithms the running time is θ (n^2). Therefore the worst case running time of quick sort is no better than that of insertion sort. Moreover, the θ (n^2) running time occurs when the input array is already completely sorted - a common situation in which insertion sort runs in O(n) time.

Best case partitioning

If the partitioning function produces two regions of size n/2 each where quicksort runs much faster. The recurrence is then becomes

$$T(n) = 2T(n/2) + \theta(n)$$

Thus this best-case partitioning produces a much faster algorithm.

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Module-8

Functions & Recursions

8.1 INTRODUCTION :

Every 'C' program is a collection of functions. In every 'C' program, main() function must be there, because the execution of program starts from main() function. **Function is a group of statements as a single unit known by some name which is performing some well defined task.** The functions which are created by programmer in a program are called as **user-defined functions**, while functions which are readily available in library are called as **library functions or built-in functions.**

Advantages of functions :

- It facilitates top-down modular programming, whereby the large problem is divided into small parts and each small part is handled later in depth.
- It reduces the size of code, if that code is repetitively used in program.
- Function can be used in other program also, so labor is reduced.
- Function can call itself, which is called as recursion, it reduces the coding, some problems are recursive in nature, at that place recursion can be used.
- It allows team-work for large project, individual members of team has to concentrate on the function given to them and not on the whole complex problem.

8.2 USER DEFINED FUNCTIONS :

User defined functions are created for doing some specific task in a program. The code is written as one unit having a name. As the size of program increases, it becomes difficult to understand, debug and maintain it. If we write the code in main() function only. When some portion of the code is repeated in the program and when there is a definite purpose of the code, we can write that part of the code as a function. So, use of function reduces the size and complexity of the program. The code of the function is written only once in the program and called for any number of times from the program whenever required.

8.3 LIBRARY FUNCTIONS :

- These are the functions which are readily available and placed inside the library. Their prototypes are declared in various header files depending on the category to which they belong to. For example, string processing functions are declared in **string.h** header file, mathematical functions are declared in **math.h** header file. We need to understand the prototype of built-in function and include that header file in our program.

10.4 HOW THE CONTROL FLOW TAKES PLACE IN MULTI-FUNCTION PROGRAM ?

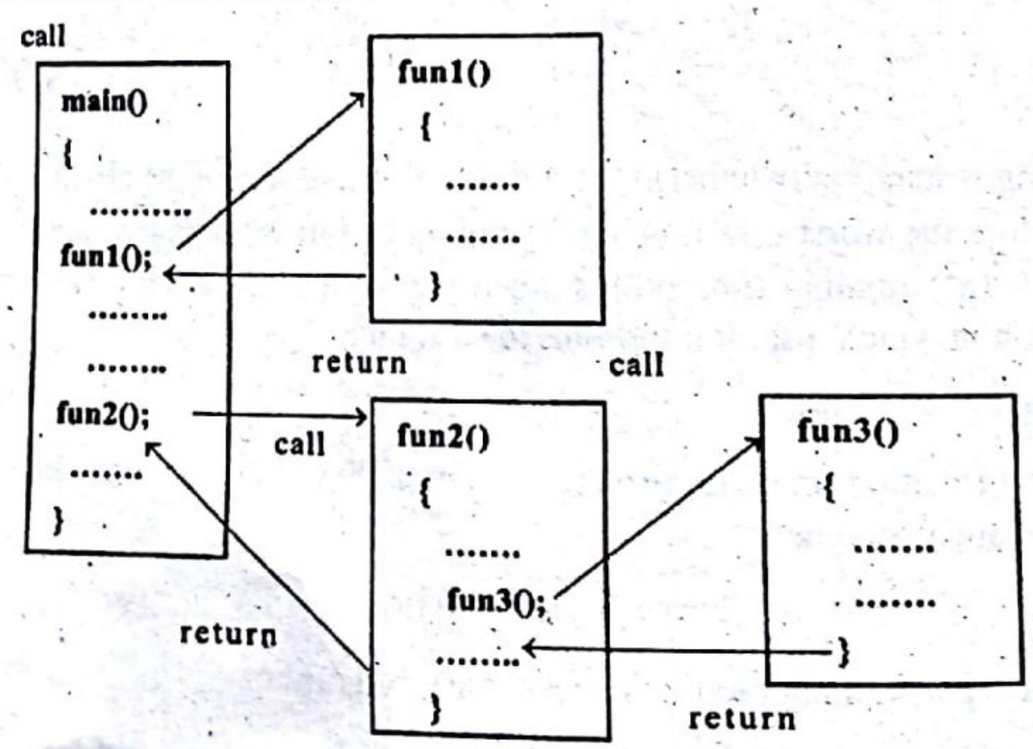

Figure 10.1

In figure 10.1, the call and return from function is explained by arrows in different directions. Above figure shows the program with main() function and three user-defined functions fun1(), fun2() and fun3(). From main() function first fun1() function is called, so code of fun1() function is executed, and control goes to the next statement after call to fun1() in main() function. Again fun2() function is called form main() function, so code of fun2() function is executed, from fun2() function internally fun3() function is called, so code of fun3() function is executed, then control returns back to next statement in fun2() statement, when last statement of function fun2() is executed, control goes back to next statement after call to fun2() in main() function.

In figure, main() function calls fun2() function which internally calls another function fun3(). When function fun3() is over, control returns to the function which called it i,e. function fun2(), when function fun2() is over, control returns back to main() function. **This is called as nesting of functions.** The nesting can be done up to any level.

With function, three things are related: declaration, definition and call. As applicable to variables, all the user defined functions must be declared before their use in the program.

8.5 FUNCTION DECLARATION :

The syntax for declaring function is:

```
type function_name(argument(s));
```

Here, type specifies the type of value returned, function_name specifies name of user-defined function, and in bracket argument(s) specifies the arguments supplied to the function as comma separated list of variables. If there are no arguments, then the bracket is left empty. The declaration of a function is terminated by semicolon (;) symbol.

The declaration is also called as prototype of a function.

Example, int sum(int x, int y); takes two integers and returns an integer

void printmessage(); takes no arguments and no return value.

8.6 FUNCTION DEFINITION :

The syntax for definition of function is :

```
type function_name(argument(s))
    {
        statement(s);
    }
```

Here, type, function_name and argument(s) have same meaning as before. The statement(s) within { } symbols indicate the body of a function. Here, the actual logic of the work of function is implemented.

If the return type is not mentioned, then by default it is taken as **int.** We can not define function inside a function. We can call one function from other. If the function return type is other than void, there must be **return** statement in the function. The returned value can be put in brackets but it is not compulsory i.e following are valid return statements.

```
return; if the return type is void.
return x;     value of x returned.
return  (x);  value of x returned.
```

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Program :

```
/* Demo of function in program */
#include <stdio.h>
#include <coino.h>
void printmessage();    /* declaration */
main()
{
  clrscr();
  printmessage();              /* call */
  getch();
}
void printmessage()          /* definition */
   {
   printf("Hello!!\n");
   }
```

Output :

```
Hello!!
```

Explanation :

In above program, the line

```
void printmessage();
```

is declaration of function printmessage, which returns no value(void), and do not require any arguments, so empty bracket (). The line is terminated by ; symbol. The above line tells the compiler that somewhere in the program printmessage will be encountered, which is a name of function, returning void.

The code,

```
void printmessage()
{
printf("Hello!!\n");
}
```

is the definition of function. In the body of function only one statement printf() is written. When the above function is called, **Hello!!** Message will be printed on screen. **Note that the definition of function is outside the main() function. There is no semicolon (;) after } symbol.**

The line in main() function,

```
printmessage();
```

is a call to the printmessage() function, so the statements in the body of function will be executed.

In above program, declaration of printmessage() function is needed. It is not necessary to write the declaration in all programs. Declaration is needed if the function definition is written after the call to the function i.e if the function definition is written before the call to the function, then declaration of the function is not required. The above program can be rewritten without using declaration of function as shown below.

Program :

```
/* Demo of function without declaration */
#include <stdio.h>
#include <conio.h>
    /* declaration of function not needed */
void printmessage()                /* definition */
    {
    printf("Hello!!\n");
    }
main()
{
clrscr();
printmessage();                    /* call */
getch();
}
```

Output :

```
Hello!!
```

Explanation :

In above program, the only change is that the definition of function is written before main() function. Because of this, declaration is not required. New sequence is definition first and then call of function in main(). **Note that in the program, if the definition comes first, and then the call to the function is made, then declaration is not needed.**

8.7 CATEGORY OF FUNCTIONS :

The functions in 'C' language can be divided in following categories :

1. Functions with no arguments and no return value
2. Functions with arguments and no return value
3. Functions with arguments and with return value.

The function example we have seen in previous programs belong to first category i.e no arguments and no return value. When we have function which takes arguments, in that case we need to understand the formal parameters and actual parameters.

The variables or parameters used in definition of function are called as formal parameters. While, parameters used in the call to the functions are called as actual parameters.

Following program shows the function with arguments but no return value.

void sum(int a, int b); declaration says that sum function takes two values but does not return any value.

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Program :

```
/* Write a program to sum given two integer numbers using function */
#include <stdio.h>
#include <conio.h>
void sum(int a, int b);          /*declaration */
main()
{
int i, j;
clrscr();
printf("Give two integer numbers\n");
scanf("%d %d",&i,&j);
sum(i,j);     /* call sum */
}
void sum(int a,int b)        /* definition */
{
    int c;
    c = a+b;
    printf("Sum of %d and %d = %d\n",a,b,c);
}
```

Output :

```
Give two integer numbers
2
3
Sum of 2 and 3 = 5
```

For example, in following program, the line

```
int sum(int a, int b);
```

is declaration of **sum** function. Here, **a and b are formal parameters.** Formal parameters are variables which are used in the body of the function and in prototype.

When a call to the function is made in main() function, the actual parameters are passed. For our example, the line

```
ans = sum(i,j);
```

calls the function **ans**, with variable i and j. **The variables i and j work as actual parameters.** Internally, the value of i is assigned to a, and that of j is assigned to b. The return type of sum function is int. So, return value of function which is int is stored in variable sum using = operator.

We can not call the function simply as .

```
sum(i,j);
```

because the function returns integer.

Whenever, a function having arguments is used, the formal parameters and actual parameters should match in

type and number. If there is a type mismatch or size mismatch, then the compiler will generate an error message. Above concepts are used in following program, **which shows the function which take arguments and also return value.**

Program :

```
/* Write a program to sum given two integer numbers using function */
#include <stdio.h>
#include <conio.h>
int sum(int a, int b);          /*declaration */
main()
{
int i, j;
int ans;
clrscr();
printf("Give two integer numbers\n");
scanf("%d %d",&i,&j);
ans = sum(i,j); /* call sum. returns integer so its
                return value stored in ans which is int*/
printf("Sum of %d and %d using function = %d\n",i,j,ans);
}
int sum(int a,int b)        /* definition */
{
    return a+b;             /* return integer value */
}
```

Output :

```
Give two integer numbers
34
56
Sum of 34 and 56 using function = 90
```

Following program explains how the user defined function can be useful if it is used inside a loop.

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Program :

```
/* Write a program to find largest of three numbers using function. Ask the user to continue or not. */
#include <stdio.h>
#include <conio.h>
int max(int a, int b, int c);  /* prototype */
main()
{
int i, j,k;
int ans;
char ch='y';            /* choice initialized to 'y'*/
clrscr();
while (ch == 'y')               /* loop */
    {
    printf("Give three integer numbers\n");
    scanf("%d %d %d",&i,&j,&k);
    ans = max(i,j,k);          /* call function */
    printf("Largest of %d, %d and %d = %d\n",i,j,k,ans);
    fflush(stdin);           /* clear input buffer */
    printf("Do you want to continue?(y/n)\n");
    scanf("%c",&ch);          /* get choice */
    }
}
int max(int a,int b,int c)  /* max defined here */
    {
      int large;
      large = a;
      if( b> large)
          large =b;
      if (c> large)
          large =c;
      return large;   /* return largest number */
    }
```

Output :

```
Give three integer numbers
23
11
56
Largest of 23, 11 and 56 = 56
Do you want to continue?(y/n)
y
Give three integer numbers
```



```
43
55
24
Largest of 43, 55 and 24 = 55
Do you want to continue?(y/n)
n
```

Explanation :

In above program, max function is user defined function. It is used inside the while loop. While loop executes till ch='y'. Here, i, j & k are actual parameters passed to function when called, while a, b & c are formal parameters. The function finds out the largest number and returns that value. The statement

```
ans = max(i,j,k);
```

stores the returned value in ans variable. The function fflush(stdin) clears the input buffer so that character reading can be done properly.

Program :

```
/* Write a program using function which receives number as argument and return sum of digits of that number */
#include <stdio.h>
int sum_digits(int num)   /* function which takes number as input and
return number of digits in that number */
{
        int sum =0;
        while (num >0)
            {
            sum = sum + num %10;
            num = num /10;
            }
        return sum;
}
main()
{
printf("\n%d\n",sum_digits(123));   /* num =123 */
printf("%d\n",sum_digits(4523));    /* num = 4523 */
}
```

Output :

```
6
14
```

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Program :

```
/* Write a program to check leap year using function. */
#include <stdio.h>
#include <conio.h>
char check_leap(int year);
                /* prototype return. type character*/

main()
{
int year;
clrscr();
printf("Enter year\n");
scanf("%d",&year);
if(check_leap(year) == 't')  /*call */
        printf("Year %d is leap year\n",year);
else
        printf("Year %d is not leap year\n",year);
}
char check_leap(int year)    /* definition */
  {
  if((year %.4 == 0) && (year %100 !=0) || (year %400 ==0))
          return 't';
      else
          return 'f';
  }
```

Output-1 :

```
Enter year
2008
Year 2008 is leap year
```

Output-2 :

```
Enter year
2009
Year 2009 is not leap year
```


Program :

```
/* Program to find HCF of given Numbers without Recursion */
#include  <stdio.h>
int  hcf(int,  int);
int  main()
{
     int  a,  b,  result;
     printf("Enter  two  numbers  to  find  their  HCF:  ");
     scanf("%d%d",  &a,  &b);
     result  =  hcf(a,  b);
     printf("The  HCF  of  %d  and  %d  is  %d.\n",  a,  b,  result);
}
int  hcf(int  a,  int  b)
{
     while  (a  !=  b)
     {
          if  (a  >  b)
          {
               a  =  a  -  b;
          }
          else
          {
               b  =  b  -  a;
          }
     }
     return  a;
}
```

Output :

```
Enter  two  numbers  to  find  their  HCF:  4  6
The  HCF  of  4  and  6  is  2.
```

8.8 SCOPE OF VARIABLES :

By scope of a variable, we mean in what part of the program the variable is accessible. In what part of the program the variable is accessible is dependent on where the variable is declared. There are two types of scope - **Local** and **Global**.

Local variables :

The variables which are declared inside the body of any function are called as local variables for that function. These variables can not be accessed outside the function in which they are declared. Thus, local variables are internal to the function in which they are defined. So far we have used all the variables as local because all the variables were declared inside of either main() function or inside user defined function.

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Global variables :

The variables which are declared outside any function definition is called as global variable. These variables are accessible by all the functions in that program, i.e all the functions in program can share global variable.

Difference between local variables and global variables :

Following table explains the differences.

Local variables	Global variables
Declared inside function body	Declared outside function body
Not initialized automatically	Initialized automatically by value 0
Use of local variables advisable	Too much use of global variables make program difficult to debug, so use with care

Following program explains the concept of local and global variables.

Program :

```
/* Write a program to sum given series using function
1 + x + x^2 + x^3 + x^4 +....+x^n */
#include <stdio.h>
#include <conio.h>
long int sum =1, term; /* global variables. so can be
            used inside all functions */
void cal_term(int x, int p)
    {
    int i;  /* local variable. its value is
        available inside this function only */
 term =1;    /* global variable accessed */
 for (i=1;i<=p;i++)
     term = term *x;
 }
 void series(int x, int n)
 {
 int i;  /* local variable. its value is
         available inside this function only.
         It is different from variable i in
         function cal_term */
 for(i=2; i<=n;i++)
    {
    cal_term(x,i);    /* call function with
                      values of x and i */
   sum =sum +term; /* global variables accessed */
```



```
    }
 printf("Answer=%ld\n",sum);
 }
 main()
 {
 int x,n;    /* local variables */
 clrscr();
 printf("Give value of x and n \n");
 scanf("%d  %d",&x,&n);
 series(x,n);
        /*call function with values of x and n */
 }
```

Output :

```
Give value of x and n
2 4
Answer=29
```

8.9 PARAMETER PASSING TO FUNCTION :

When a function is called from other function, the parameters can be passed in two ways.

- Call by value
- Call by reference

In call by value, argument values are passed to the function, the contents of actual parameters are copied into the formal parameters. The called function can not change the values of the variables which are passed. Even if a function tries to change the values of passed parameters, those changes will occur in formal parameters, not in actual parameters.

Example :

In all the programs which have seen so far, use call by value, where we pass the value of actual parameter. In previous program the call

```
series(x,n);
```

and

```
cal_term(x,i);
```

are examples of call by value.

In call by reference, as the name suggests, the reference of the parameter **i.e address (pointer)** is passed to the function and not the value. Because pointer is passed, the called function can change the content of the actual parameter passed. **Call by reference is used whenever we want to change the value of local variables declared in one function to be changed by other function.**

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Program :

```
/* Write a program to exchange the value of two variables using function*/
#include <stdio.h>
#include <conio.h>
void exch(int a, int b)
{       /* a and b formal parameters */
    int temp;
    temp=a;
    a=b;
    b=temp;
    printf("Printing from inside exch function\n");
    printf("a = %d b = %d\n",a,b);
                    /* local copies exchanged */
}
main()
{
    int x,y;    /* local variables */
    clrscr();
    printf("Give value of x and y \n");
    scanf("%d %d",&x,&y);
    exch(x,y);
        /*call by value. x and y actual parameters*/
    printf("Printing from main function\n");
    printf("x = %d y = %d\n",x,y);
                    /* x and y remain unchanged */
}
```

Output :

```
Give value of x and y
3
5
Printing from inside exch function
a = 5 b = 3
Printing from main function
x = 3 y =5
```

Above program is not working as per our expectation, the values of x and y which are declared inside the main function are not changed. The exch() function logic is correct, and it is able to exchange the values of a and

b inside function. The problem is that we are trying to change the values of variables x and y (which are local to main() function) by outside function exch() function using call by value, which is not possible.

We should use call by reference to get the correct answer i.e exch() function definition and call to exch() function should be modified to use call by reference. In call by reference, we pass the address of the variable, and the formal parameters should be declared as pointers of appropriate type.

So, call to exch() function should be written as

```
exch( &x, &y);
```

& symbol specifies address of

and the prototype of exch() function should be written as

```
exch(int *a, int *b)
```

so, **call to exch() function assigns address of x to variable a and address of y to variable b.** Now, the exch() function has the address of actual parameters, so it is able to change the values of actual parameters. It is shown in following program.

Program :

```
/* Write a program to exchange the value of two variables using function */
#include <stdio.h>
#include <conio.h>
void exch(int *a, int *b)
{   /* a and b formal parameters which are pointers*/
    int temp;
    temp=*a;
    *a=*b;
    *b=temp;
    printf("Printing from inside exch function\n");
    printf("a = %d b = %d\n",*a,*b);
                    /* local copies exchanged */
}
main()
{
    int x,y;    /* local variables */
    clrscr();
    printf("Give value of x and y \n");
    scanf("%d %d",&x,&y);
exch(&x,&y);
 /*call by reference. x and y actual parameters*/
printf("Printing from main function\n");
printf("x = %d y = %d\n",x,y);
                    /* x and y are changed */
}
```

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Output :

```
Give value of x and y
3
5
Printing from inside exch function
a = 5 b = 3
Printing from main function
x = 5 y = 3
```

If we execute following code,

```
void main()
{
    int x[] = {1,2,3,4,5};
    printf("%d",fun(&x[2]));
}
int fun(int *a)
{
    int i=0,sum=0;
    for(i=0;i<2;i++,a++)
        sum += *a;
    return(sum);
}
```

In above program, mai ;) function calls function fun() with call by pointer value.

Statement	Effect
int x[] = {1,2,3,4,5};	x[0]= 1, x[1]=2 ... x[4]=4
printf("%d",fun(&x[2]));	Call to function fun with address of x[2], so *a = x[2]=3
int i=0,sum=0;	i=0, sum=0
for(i=0;i<2;i++,a++)	sum += *a; sum = sum + x[2] so, sum = 0+3 =3 sum = sum + x[3] so, sum = 3 +4 =7
return(sum);	Return value 7 to main() which is printed by main() function

So, output

```
7.
```

8.10 RECURSION :

Sometimes, the function is defined in terms of itself. For example factorial of a number, we can say that N! = N * (N-1)!. Here, factorial of N is defined in terms factorial of N-1.

Again (N-1)! = N-1 * (N-2)! and so on. We can write the function which calls itself internally. **Thus, recursion is the process by which a function calls itself. Because the function calls itself, there must be some condition to stop recursion; otherwise it will lead to infinite loop.** The condition to stop recursion is called as terminating condition. For above example of factorial, the terminating condition is 0! = 1. Thus,

N! = N * (N-1) !

0! = 1 terminating condition.

Types of recursion :

There are two types of recursion based on how recursion takes place: Direct recursion and indirect recursion. In the case of direct recursion, a function explicitly calls itself. While in the case of indirect recursion, the function calls another function, which ultimately calls the caller function.

Example of indirect recursion,

fun1()
{
....
fun2()
...
}
	fun2()
	{
	...
	fun1()
	...
	:

ADVANTAGES OF RECURSION :

- Easy solution for recursively defined problems.
- Complex programs can be easily written in less code.

DISADVANTAGES OF RECURSION :

- Recursive code is difficult to understand and debug.
- Terminating condition is must, otherwise it will go in infinite loop.
- Execution speed decreases because of function call and return activity many times.

Program :

```
/* Write a program to find factorial of a given number using recursion */
#include <stdio.h>
#include <conio.h>
long int fact(int n);     /* prototype of function */
main()
{
int m;
long int ans;     /* long int store large number */
clrscr();
printf("Give the number\n");
scanf("%d", &m);
ans = fact(m);
     /* call function fact() with call by value*/
```

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```
printf("Factorial of %d using function = %ld\n",m,ans);
}
long int fact(int n)  /* function body here */
{
    if (n==1)  /* condition to terminate recursion */
        return 1;
    else
        return  n* fact(n-1); /* recursion here. fact()
                                 calls fact() internally*/
}
```

Output :

```
Give the number
6
Factorial of 6 using function = 720
```

Program :

```
/* Write a program to calculate nCr  using function
nCr  = n! / (r ! * (n-r) !  */
#include <stdio.h>
#include <conio.h>
long int fact(int n);
main()
{
int n,r;
long int ans;
clrscr();
printf("Give the values of n and r \n");
scanf("%d%d",&n,&r);
if ( n<0 || r <0 || n<r)
    printf("Input data invalid\n");
else
{
    ans = fact(n) / (fact(r) * fact(n-r));
    printf("Answer = %ld\n",ans);
}
}
```



```
long int fact(int n)
{
if (n==0)  /* condition to terminate recursion */
    return 1;
else
    return  n* fact(n-1); /* recursion here. fact()
                             calls fact() internally*/
}
```

Output-1 :

```
Give the values of n and r
6 6
Answer = 1
```

Output-2 :

```
Give the values of n and r
10 7
Answer = 120
```

Similarly, we can calculate x^y using recursion. We can write

$$x^y = x * x^{(y-1)}$$

$x^0 = 1$, terminating condition i.e y =1.

Program :

```
/* Sum of digits using Recursive function*/
#include<conio.h>
#include<stdio.h>
int  sumofdigit(int  x);
void  main()
{
    int  n,sum;
    printf  ("Enter  Integer  number  \n");
    scanf("%d",&n);
    sum=sumofdigit(n);
    printf  ("Sum  of  Digits  %d\n",  sum);
    getch();
}
    /*  Recursive  Function  sum  of  digits  */
    int  sumofdigit(int  x)
    {
    int  s=0,d;
```

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```
    if(x  ==  0)
        return  (0);
    d=  x%10;
    s=  s  +  d  +  sumofdigit(x/10);
    return(s);
}
```

Output :

```
Enter  Integer  number
345
Sum  of  Digits  12
```

Program :

/*Write a program to calculate x^y using recursive function */

```
#include <stdio.h>
#include <conio.h>
int power(int a, int b); /* prototype of function */
main()
{
int x,y;
int ans;
clrscr();
printf("Give the numbers x and y\n");
scanf("%d%d",&x, &y);
ans = power(x,y);          /* call function */
printf("%d^%d = %d\n",x,y,ans);
}
int power(int a, int b)  /* function body here */
{
        if (b==0)/* condition to terminate recursion */
        return 1;
    else
        a * power(a,b-1);/* recursion here. */
}
```

Output :

```
Give the numbers x and y
2 5
2^5 = 32
```

Similarly, we can write a function for generating Fibonacci numbers recursively. Because Fibonacci series is recursive in nature, current number is generated by adding previous two Fibonacci numbers. We can pass the two previous numbers as an argument as well as the number of Fibonacci numbers remaining to be generated. Here, the terminating condition will be the number of Fibonacci numbers yet to be generated becoming zero. i.e function prototype will be

```
fibo(int n1,int n2,int n);
```


where, n1,n2 are previous fibonacci numbers and n is the numbers yet to be generated. As long as n > 0, fibo() function will call itself, when n=0, recursion terminates.

Program :

/*Program to calculate Highest Common Factor (HCF) of three integers */

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

int  hcf(int  x,  int  y);
void  main()
{
    int  a,b,c,h;
    clrscr();
    printf("  ENTER  3  integers  \n");
    scanf("%d%d%d",&a,&b,&c);
    h=hcf(hcf(a,b),c);
    printf("HCF  =  %d\n",h);
    getch();
}

int  hcf(int  x,int  y)
{
    while(x!=y)
    {
        if(x>y)
        x=x-y;
        else
        y=y-x;
    }
    return  x;
}
```

Output1 :

```
ENTER  3  integers
6
12
15

HCF  =  3
```

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Output2 :

```
ENTER  3  integers
34
22
12

HCF  =  2
```

8.11 PARAMETERS AS ARRAY :

We can pass the whole array as a parameter to the function. We have already studied in the chapter on pointers that the name of an array is a pointer to the first element of an array. So, if we pass the name of an array as an argument, we are effectively passing whole array as an argument. Naturally, passing an address of an array is call by reference.

Following program explains how whole array can be passed as an argument to the function. In this program, two user defined functions calculate() and input() are used. From main() function these two functions are called with array as parameter as

```
input(x,n);
```

and

```
calculate(x,n);
```

where, x is the array name.

Program :

```
/* Write a program to sum and average the given numbers using function */
#include <stdio.h>
#include <conio.h>
int calculate(int a[], int n)
        /* calculates sum and average of array data*/
    {
    int i,sum=0;
    float avg;
    for(i=0;i<n;i++)
        sum = sum +a[i];
    avg = (float)sum/n;
    printf("Sum of values = %d and Average  = %5.2f\n",sum,avg);
    }
void input(int a[], int n)
                /* gets data in array from user */
    {
    int i;
    for(i=0; i<n;i++)
        {
        printf("Enter value %d\n",i+1);
```



```
        scanf("%d",&a[i]);
        }
    }
main(  )
{
    int x[20],n;
    clrscr();
    printf("How many numbers?\n");
    scanf("%d",&n);
    input(x,n);    /* call function to get data and
                      store in array. Whole array passed */
    calculate(x,n); /* call function to process
                       the data. Whole array passed */
}
```

Output :

```
How many numbers?
Enter value 1
1
Enter value 2
2
Enter value 3
3
Enter value 4
4
Enter value 5
5
Enter value 6
6
Sum of values = 21 and Average  =  3.50
```

Following program explains how two-dimensional array can be passed as a parameter to the function. Here, also if we pass the name of an array, whole two-dimensional array is passed to the function.

Program :

```
/* Write a program to sum major diagonal elements of square matrix
 (number of row and columns same)  using function */
#include <stdio.h>
#include <conio.h>
int calculate_major(int a[][5], int m, int n)
                                /* calculates sum */
```

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```
        {       /* int a[][5] number of rows not
                   needed in formal parameter */

    int i,j,sum=0;
    for(i=0;i<m;i++)
        for(j=0;j<n;j++)
            if (i == j) /* check diagonal element */
                sum = sum + a[i][j];
    printf("Summation of diagonal elements is =
                                %d\n",sum);

}
void input(int a[][5], int m, int n)
                /* gets data in array from user */
                /* in two-dimensional array number
                   of rows not required */

    {
    int i,j;
    for(i=0; i<m;i++)
        {
        printf("Give row %d data\n",i+1);
        for(j=0;j<n;j++)
            scanf("%d",&a[i][j]);
        }
    }
main()
{
    int x[5][5],m,n; /* x is two-dimensional matrix */
    clrscr();
    printf("What is the size of matrix?   ");
    scanf("%d",&m);
    n= m;      /* row and columns same */
    input(x,m,n);
    /* call function to get data and store in array */
    calculate_major(x,m,n);
            /* call function to process the data */
}
```


Output :

```
What is the size of matrix?
4
Give row 1 data
1 2 3 4
Give row 2 data
5 6 7 8
Give row 3 data
2 3 4 5
Give row 4 data
6 7 8 9
Summation of diagonal elements is = 20
```

8.12 PARAMETERS AS STRING :

Actually, it is character array as parameter, because string is stored in a single dimensional array of character type. In the chapter on arrays and strings we have used the built-in string functions for manipulating strings. We can write user defined functions to manipulate strings. In this section, we will understand how a string or collection of strings can be passed as a parameter to a function.

The next program shows how the user defined function for finding length of a string can be written. Here, length() is a user-defined function, which takes pointer to character as an argument, and returns integer value.

Program :

```
/* Write a program to find length of a given string with user defined function */
#include <stdio.h>
#include <conio.h>
int length(char *s)
    {
    int cnt=0;
    while(*s != NULL)
        {
        s++;
        cnt++;
        }
    return cnt;
    }
main()
{
    char str[20];
    int len;
    clrscr();
```

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```
    printf("Enter a string\n");
    gets(str);
    len =length(str);
    printf("Length of string %s = %d\n",str,len);
}
```

Output :

```
Enter a string
vansh
Length of string vansh = 5
```

Next program shows how we can write the user-defined function to reverse given string. The function internally counts the length of string passed. Then the function maintains two variables one starting from first character and the other starting from the last character of the string and then exchanges first character with last character, second character with second last character and so on till both variable values cross each other.

Program :

```
/* Write a program to reverse a given string with user defined function*/
#include <stdio.h>
#include <conio.h>
void reverse(char s[])
    {
    int i,j,len,temp;
    len=0;    /* length of string initialized to 0 */
    while(s[len] != NULL)
        len++;
    j=len-1;     /* last character in string
                    at length -1 position */
    for(i=0; i<j; i++)
        {              /* exchange s[i] and s[j] */
        temp = s[i];
        s[i]= s[j];
        s[j]= temp;
        j--;
        }
    }
main()
{
char str[20];
int len;
```



```
clrscr();
printf("Enter a string\n");
gets(str);
    printf("Reverse of %s is ",str);
    reverse(str);
    printf(" %s \n",str);
}
```

Output :

```
Enter a string
Mahajan
Reverse of Mahajan is  najahaM
```

Following program explains use of array of strings with functions. As we have already studied, we require two-dimensional character array to store array of characters.

Program :

```
/* Write a program that takes input student name and their 3 subject marks and calculate total marks and
display the data on screen using function */
#include <stdio.h>
#include <conio.h>
void disp(char stud[10][20], int mark[10][3],int n);
                                        /* prototype of function */
void starline();
main()
{
char names[10][20];  /* assuming max 10 students */
int marks[10][3];
int i,j,n;
clrscr();
printf("How many students?\n");
scanf("%d",&n);
for(i=0;i<n;i++)
    {
    printf("Enter name of student\n");
    scanf("%s",names[i]);
    printf("Enter 3 subject marks (out of 100)
                                in sequence\n");
    for(j=0;j<3;j++)
        scanf("%d",&marks[i][j]);
```

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```
    }
starline();
disp(names,marks,n);
}
void starline()   /* prints line of 50 stars */
{
int i;
for(i=0;i<50;i++)
    putchar('*');
printf("\n");
}
void disp(char stud[][20], int mark[][3],int n)
{  /* displays student name, subject marks and total */
    int i,j,tot;
    for(i=0;i<n;i++)
        {
        tot =0;
        puts(stud[i]);
        for(j=0;j<3;j++)
            {
            printf("%d",mark[i][j]);
            tot = tot + mark[i][j];
            }
        printf("Total = %d\n",tot);
        starline();
        }
}
```

Output :

```
How many students?
3
Enter name of student
sanjay
Enter 3 subjects marks (out of 100) in sequence
69 75 70
Enter name of student
paresh
Enter 3 subjects marks (out of 100) in sequence
68 76 68
```



```
Enter name of student
milan
Enter 3 subjects marks (out of 100) in sequence
40 50 45
**************************************************
sanjay
69 75 70 Total = 214
**************************************************
paresh
68 76 68 Total = 212
**************************************************
milan
40 50 45 Total = 135
**************************************************
```

8.13 FUNCTION RETURNING A POINTER :

Till now we have seen functions that take arguments as pointers and returning only the standard data type. We can have a function which does not return a value but a pointer to a value. The prototype of a function returning a pointer is

```
data_type   *func_name(arguments);
```

Here, * before the name of a function means that the function returns a pointer of the data_type mentioned. So, in the calling function the value must be assigned to a pointer of the appropriate type.

Following program explains these concepts.

Program :

/* Write a program to find out largest of two numbers using a function which returns a pointer to the largest number. */

```
#include <stdio.h>
#include <conio.h>
int *large(int a, int b);
main()
{
    int x,y, *ptr;
    clrscr();
    printf("Give two numbers  ");
    scanf("%d%d",&x, &y);
    ptr = large(x,y);
    printf("Larger of %d and %d is %d\n",x,y,*ptr);
}
int *large(int a, int b)
    {
    int *p, *q;
    p = &a;
    q = &b;
    if (*p > *q)
        return p;
```

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```
    else
        return q;
    }
```

Output :

```
Give two numbers
3 5
Larger of 3 and 5 is 5
```

Note following difference

```
int  *f(int,int);
```

Here, f is a function returning a pointer to an integer.

```
int  (*f)(int,int)
```

Here, f is a pointer to a function returning an integer.

8.14 STORAGE CLASSES :

The storage class of a variable determines the scope and lifetime of a variable. The variable values can be stored in computer memory or in registers of CPU. There are four storage classes

- Auto
- Register
- Static
- External

The storage class of a variable decides where the variable will be stored, what will be the default value, what is the scope and what is the life time of a variable.

The syntax for giving storage class to a variable is :

```
storage_specifier data_type variable_name;
```

Auto :

If we do not specify the storage specifier with variable, by default it is auto. All the local variables have auto storage class. Auto variables are **stored in memory, garbage initial value, scope local to function** and **lifetime till the control remains in that function.** As the name suggests, auto variables are created when the function is called and destroyed automatically when the function terminates.

Following program explains the use of auto variables. Remember that all the local variables are by default have auto storage space.

Program :

```
/* Write a program to uses auto variables */
#include <stdio.h>
#include <conio.h>
void fun1();
main()
    {
    auto int a = 100;
    clrscr();
```



```
    fun1(); /* call function */
    printf("%d\n",a);
}
void fun1()
{
auto float a = 25.5;
printf("%f\n",a);
}
```

Output :

```
25.500000
100
```

Register :

Variables which are to be stored in the registers of CPU are called as register variables. **register** keyword is used for that purpose, for example,

```
register int a;
```

declares the variable a as register variable. Register storage class should be used for variables which require fast access. As the number of registers of a CPU is limited, we can have limited number of register variables. If the value can not be stored in the register, the compiler may convert register variable to non-register variable. **Storage of register variable take place in registers, have garbage value, scope local to function and are created when the function is called and destroyed automatically when the function terminates.**

Static :

All the global variables are by default of static storage class. Default value of static variable is 0. Static global variable is available throughout the entire file in which it is declared, while static local variable is available in the function in which it is defined, but is initialized only once and retains its value even when the control goes out of the function.

So, static variables are **stored in memory, default initial value 0, scope is local to function or file in which declared** and **lifetime is entire program execution with retaining values between function calls.**

Following program explains the use of static variable. Static variable preserves its value between function calls i.e it retains its value even if the function in which it is declared terminates till the end of the program. The variable n in fun1() is declared as static with initial value of 2. This function is called 5 times from main() function. Every time the function fun1() doubles latest value of n. This is possible because variable n is declared as static.

Program :

```
/* Write a program demonstrating static variables */
#include <stdio.h>
#include <conio.h>
void fun1();
main()
    {
    int i;
    clrscr();
```

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```
    for (i=1; i<=5; i++)
        fun1(); /* call function */
    }
void fun1()
    {
    static int n=2;
        /* static variable initialized only once */
    n = n *2;
    printf("n = %d\n",n);
    }
```

Output :

```
n = 4
n = 8
n = 16
n = 32
n = 64
```

Extern :

Normally, the scope of global variable starts from its definition up to the end of the program. So, the functions which are defined before the definition of global variable can not access it.

Consider following scenario :

```
main()
{
.....
.....
}
int a;  /* global variable after definition
           of main() function */
void fun1()
{
.....
.....
}
```

In this scenario, even though variable a is global, it is not available in main() function because a is defined below the definition of main() function. To allow access of variable a in main() function, we have to use extern storage class in the declaration as shown below.

```
main()
{
extern int a;    /* extern declaration i.e this variable
                    is already declared some where else */
.....
```



```
.....
}
int a;              /* global variable after definition
                       of main() function */
void fun1()
{
.....
.....
}
```

Above example shows the use of extern in one file only.

When a program is divided into two or more files, and we want one variable to be available in all the files of a program, we use a variable with extern storage class. For example, the declaration

```
extern int  a;
```

in one file, it means that the variable named as a is already declared in some other file and there is no nee. to allocate memory to it. **Storage in memory, default initial value 0, scope is global all the files of program and life is entire program execution.**

Following table explains how we can share a global variable between two different .c files and we can compile both the .c files separately without compilation error. Later on both .c files can be made as a part of a project and project can be run as one .exe file. The linker will take care of other things.

File1.c	File2.c

`#include <stdio.h>`
`int a;`
`void fun1();`
`main()`
`{`
`a=10;`
`clrscr();`
`printf("Value of a =`
`%d\n",a);`
`fun1();`
`}`
	`#include <stdio.h>`
	`extern int a;`
	`void fun1()`
	`{`
	`a=a + 10;`
	`printf("Value of a =`
	`%d\n",a);`
	`}`

Steps for creating project are :

- Write file1.c
- Write file2.c
- Open new project as test.prj

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- Add item as file1.c
- Add item as file2.c
- Run the project file test.prj

Output :

```
Value of a = 10
Value of a = 20
```

Following are some of the important differences between auto and static storage class

Auto	Static
Declaration: auto int a;	Declaration: static int a;
It is the default storage class for local variables	It is the default storage scope for global variables
Default initial value is 0	Default initial value is garbage
The life time is from function call to function termination	Life time is till program execution
Initialized every time function called	Initialized only once
Does not retain value between function calls	Retain value between function calls

8.15 SOLVED PROGRAMMING EXAMPLES :

Program :

/* Write a program to print even numbers up to N using recursive function */

```
#include <stdio.h>
#include <conio.h>
void even(int a, int n);
main()
{
    int n;
    clrscr();
    printf("Give value of n  ");
    scanf("%d",&n);
    even(0,n);
}
void even(int a, int n)
   {
   if (a <=n)
      {
      printf("%d ",a);
      even(a+2,n);
      }
```



```
   else
      return;
   }
```

Output :

```
Give value of n  13
0 2 4 6 8 10 12
```

Program :

/* Write a program using function which rounds given real number into its nearest integer without using library function. */

```
#include <stdio.h>
int nearest(float x)
{
        int num;
        float temp;
        num = x;
        temp = x - num;
        if (temp > 0.5)
            return num +1;
        else
            return num;
}
main()
{
        float a;
        int ans;
        printf(" Give one real number\n");
        scanf("%f", &a);
        ans = nearest(a);
        printf("Nearest number = %d\n",ans);
}
```

Output :

```
Give one real number
3.123
Nearest number = 3
```

Program :

/* Write a program to calculate perimeter of a square and rectangle using function. Perimeter of a square = 4*l, while perimeter of rectangle
= 2 *l + 2 *b */

```
#include <stdio.h>
#include <conio.h>
void peri_square(int l);
void peri_rectangle(int l, int b);
main()
```

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```
{
    int choice;
    int l,b;
    clrscr();
    for(;;)
      {
      printf("1 Square\n");
      printf("2 Rectangle\n");
      printf("3 Exit\n");
      scanf("%d",&choice);
      if (choice ==1)
        {
        printf("Give size\n");
        scanf("%d",&l);
        peri_square(l);
        }
      else if (choice ==2)
        {
        printf("Give length and width\n");
        scanf("%d%d",&l,&b);
        peri_rectangle(l,b);
        }
      else if (choice ==3)
          break;
      }
}
void peri_square(int l)
    {
printf("length = %d Perimeter of square = %d\n",l,4*l);
    }
void peri_rectangle(int l, int b)
    {
printf("length = %d width = %d Perimeter of rectangle  = %d\n",l,b,2*l
+2*b);
    }
```

Output :

```
1 Square
2 Rectangle
3 Exit
2
Give length and width
```



```
3 4
length = 3 width = 4 Perimeter of rectangle = 14
1 Square
2 Rectangle
3 Exit
3
```

Program :

/* Write a C function to exchange two numbers and use it to reverse an array of 10 integers accepted from user. */

```
#include<stdio.h>
#include<string.h>
void  exch(int  *a  ,  int  *b)
    {
    int  temp;
    temp  =  *a;
    *a  =  *b;
    *b  =  temp;
    }

main()
{
int  x[10]=  {1,2,3,4,5,6,7,8,9,10};

int  i;
for(i=0;i<5;i++)
    {
    exch(&x[i],&x[9-i]);
    }
for(i=0;  i<10;i++)
    printf("%d  ",x[i]);
}
```

Output :

```
10  9  8  7  6  5  4  3  2  1
```

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Program :

```
/* Write a program to check whether the number is prime or not using function */
#include <stdio.h>
#include <conio.h>
int isprime(int num);
main()
{
    int n;
    clrscr();
    printf("Give number to be checked for prime ");
    scanf("%d",&n);
    if (isprime(n))
        printf("Number %d is prime\n",n);
    else
        printf("Number %d is not prime\n",n);
}
int isprime(int num)
{
    int i;
    for(i=2;i<num;i++)
        if (num %i ==0)
            return 0;
    return 1;
}
```

Output-1 :

```
Give number to be checked for prime 35
Number 35 is not prime
```

Output-2 :

```
Give number to be checked for prime 13
Number 13 is prime
```


Program :

```
/* Write a program to convert given number to binary using function */
#include <stdio.h>
#include <conio.h>
void convert_to_bin(int num);
main()
{
    int n;
    clrscr();
    printf("Give number to be converted to binary ");
    scanf("%d",&n);
    convert_to_bin(n);
}
void convert_to_bin(int num)
{
    unsigned int bin[16];
    int i, m =15; /* assuming max 16 bits */
    while ( num !=0)
        {
        bin[m] = num %2;
        m--;
        num = num /2;
        }
    printf("The binary equivalent = ");
    for(i=++m; i<= 15; i++)
        printf("%u",bin[i]);
}
```

Output-1 :

```
Give number to be converted to binary 128
The binary equivalent = 10000000
```

Output-2 :

```
Give number to be converted to binary 108
The binary equivalent = 1101100
```

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: LIBRARY FUNCTION :

Important functions of <math.h> file

Function	Syntax	Meaning
acos(d)	double acos(double d)	Returns arc cosine of d
asin(d)	double asin(double d)	Returns arc sine of d
atan(d)	double atan(double d)	Returns arc tangent of d
ceil(d)	double ceil(double d)	Returns a value rounded up to next higher integer of d
floor(d)	double floor(double d)	Returns a value rounded up to largest integer which is lower than d
cos(d)	double cos(double d)	Returns cosine of d
sin(d)	double sin(double d)	Returns sine of d
tan(d)	double tan(double d)	Returns tangent of d
exp(d)	double exp(double d)	Finds ed
log(d)	double log(double d)	Returns natural logarithm of d, positive number
log10(d)	double log10(double d)	Returns logarithm to the base 10 of d, positive number
pow(d1,d2)	double pow(double d1, double d2)	Finds d1 raised to the power d2 i.e. d1d2
sqrt(d)	double sqrt(d)	Returns square root of number d, positive number

Important functions of <ctype.h> file

Function	Syntax	Meaning
isalpha(c)	int isalpha(int c)	Returns TRUE if c is alphabet, otherwise returns FALSE
islower(c)	int islower(int c)	Returns TRUE if c is lower case letter, otherwise returns FALSE
isupper(c)	int isupper(int c)	Returns TRUE if c is upper case letter, otherwise returns FALSE
isdigit(c)	int isdigit(int c)	Returns TRUE if c is digit, otherwise returns FALSE
isalnum(c)	int isalnum(int c)	Returns TRUE if c is letter or digit, otherwise returns FALSE
isprint(c)	int isprint(c)	Returns TRUE if c is printable character, otherwise returns FALSE
ispunct(c)	int ispunct(c)	Returns TRUE if c is punctuation mark (like , ; : etc), otherwise returns FALSE
isspace(c)	int isspace(c)	Returns TRUE if c is white space like blank, tab or newline, otherwise returns FALSE

: MCQs :

1. Function which is readily available in library is called
   (a) User defined function (b) Built in function
   (c) Library function (d) Both b and c
2. Function which does not return any value has return type as
   (a) void (b) null (c) Nil (d) None of above
3. What is the return type of a function of which return type is not specified?
   (a) double (b) char (c) float (d) None of above

4. In nesting of a function, one function is defined inside another function
   (a) True (b) False
   (c) Both True and false as the case may be
5. In function, _____ parameters are used in definition of function, while _____ parameters are used in function call.
   (a) Formal, actual (b) local, global (c) Actual, Formal (d) None of above
6. While using functions, actual and formal parameters must match in type and numbers
   (a) False (b) True (c) Not always True (d) Not always False
7. _____ variables are declared inside function body, while _____ variables are declared outside function body.
   (a) Global, local (b) Static, Dynamic (c) Local, dynamic (d) Dynamic, static
8. _____ variables are initialized automatically to value 0.
   (a) Local (b) int (c) Global (d) Static
9. If we want to change the value of actual parameters, by the function body i.e function we need to use
   (a) Call by value (b) call by reference (c) Both a and b
10. The statement exch(&x, &y); is
    (a) Definition (b) call by value (c) call by reference (d) declaration
11. For the function call exch(&x, &y);
    What should be the prototype assuming x and y are integers?
    (a) exch(int a , int b); (b) exch (int , int);
    (c) exch (int *a, int *b); (d) None of above
12. Which are the features of recursion?
    (a) decreases code (b) difficult to understand
    (c) reduces speed of program (d) All of above
13. If we pass the name of an array as an argument in function call, we are passing _____ elements of an array to function.
    (a) First (b) last (c) all (d) some
14. _____ variables retain values between function calls.
    (a) Static (b) Register (c) Auto (d) External
15. _____variables are initialled only once, while _____ variables are initialized every time function is called.
    (a) Local, Global (b) Static, Auto (c) Auto, Static (d) Global, Local
16. What is the value returned by floor(10.5);?
    (a) 11 (b) 10 (c) 0 (d) None of above
17. Recursion is a process in which a function calls
    (a) itself (b) another function (c) main() function (d) none of the above
18. Following is an example of user defined function.
    (a) printf (b) scanf (c) test (d) main
19. Which of the following is element of function definition?
    (a) Function name (b) Parameter list (c) Function type (d) Above all
20. A function without return statement is legal.
    (a) True (b) Can't say (c) False (d) None
21. Function returns _____ value by default.
    (a) Char (b) Integer (c) Float (d) Void

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22. Parameter passing technique in C language is:
(a) Call by Reference (b) Call by Value (c) Both a & b (d) None

23. What does the statement declare?
int (*T)[10];
(a) T is only array of 10 elements (b) T is an array of 10 pointers
(c) T is pointer to an array of 10 integer (d) None

24. main( )
{ a( ); }
void a( )
{ int x=5; printf("%d",++x); }
(a) 5 (b) 6 (c) 0 (d) 4

25. main( )
{ int x=25, y=5;
printf("%d", m(x,y));
}
int m(int a, int b)
{ return(a%b); }
(a) 0 (b) 25 (c) 5 (d) None of above

26. Default value of local variable is
(a) Garbage Value (b) 0 (c) 1 (d) depend on data type

: ANSWERS :

1. (d)	2. (a)	3. (d)	4. (b)	5. (a)	6. (b)	7. (c)
8. (c)	9. (b)	10. (c)	11. (c)	12. (d)	13. (c)	14. (a)
15. (b)	16. (b)	17. (a)	18. (c)	19. (d)	20. (a)	21. (b)
22. (c)	23. (d)	24. (b)	25. (a)	26. (a)		

: LONG QUESTIONS ANSWERS :

1. What is user-defined function? Explain actual argument and formal argument.

Ans:

Function is a group of statements as a single unit known by some name which is performing some well defined task. The functions which are created by programmer in a program are called as user-defined functions.

When some portion of the code is repeated in the program and when there is a definite purpose of the code, we can write that part of the code as a function. So, use of function reduces the size and complexity of the program.

Formal arguments are the arguments which are used in the definition of a function, while actual arguments are the arguments which are used while calling a function. Following example explains formal and actual arguments using user defined max function..

```
#include <stdio.h>
int max( int x, int y)
{
    if (x >y)
        return x;
    else
        return y;
}
main()
{
```



```
int a=5, b=3;
int ans;
ans = max(a,b);
printf("Maximum = %d\n", ans);
}
```

In above program, x and y are formal parameters, while a and b are actual parameters.

3. What are the different categories of functions? Explain any one category with example.

Ans:

The functions in 'C' language can be divided in following categories:

1. Functions with no arguments and no return value
2. Functions with arguments and no return value
3. Functions with arguments and with return value.

Following program explain the use of second category of function i.e function with arguments and no return value.

```
#include <stdio.h>
void sum(int a, int b);          /*declaration */
main()
{
int i, j;
clrscr();
printf("Give two integer numbers\n");
scanf("%d %d",&i,&j);
sum(i,j);     /* call sum */
}
void sum(int a,int b)        /* definition. No return
                                value and two arguments*/
{
    int c;
    c = a+b;
    printf("Sum of %d and %d = %d\n",a,b,c);
}
```

6. What do you mean by recursive function? Explain with example.

Ans:

Recusrive function is a function which calls itself. For example factorial of a number, we can say that N! = N * (N-1)!. Here, factorial of N is defined in terms factorial of N-1.

Again (N-1)! = N-1 * (N-2)! and so on.

Thus, recursion is the process by which a function calls itself. Because the function calls itself, there must be some condition to stop recursion; otherwise it will lead to infinite loop. The condition to stop recursion is called as terminating condition. For above example of factorial, the terminating condition is 0! = 1. Thus,

N! = N * (N-1) !

0! = 1 terminating condition.

Following program explains the use of recursion.

```
#include <stdio.h>
long int fact(int n);    /* prototype of function */
```

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```
main()
{
int m;
long int ans;            /* long int store large number */
clrscr();
printf("Give the number\n");
scanf("%d",&m);
ans = fact(m);                    /* call function fact() with call by value*/
printf("Factorial of %d using function = %ld\n",m,ans);
}
long int fact(int n)  /* function body here */
{
    if (n==1)    /* condition to terminate recursion */
        return 1;
    else
        return  n* fact(n-1); /* recursion here. fact()
                                                    calls fact() internally*/
}
```

12. Write the syntax of function in 'C'. Write sample program to demonstrate "function with arguments and return value"

Ans:

The syntax for declaring function is:

type function_name(argument(s));

Here, type specifies the type of value returned, function_name specifies name of user-defined function, and in bracket argument(s) specifies the arguments supplied to the function as comma separated list of variables. The declaration of a function is terminated by semicolon (;) symbol.

Function with arguments and return values:

The function which takes some values as input and returns one value as output is as explained and its definition is written as

```
int max( int x, int y);
```

Here, the return value is Integer type and the function takes two Integer values as input.

The program for finding maximum of two numbers using function can be written as below.

```
#include <stdio.h>
int max( int x, int y)
{
    if (x >y)
        return x;
    else
        return y;
}
main()
{
```



```
int a=5, b=3;
int ans;
ans = max(a,b);
printf("Maximum = %d\n", ans);
}
```

13. What is scope, visibility and life time of variables? Explain static variables with example.

Ans:

By scope of a variable, we mean in what part of the program the variable is accessible. In what part of the program the variable is accessible is dependent on where the variable is declared. There are two types of scope -- **Local** and **Global**.

Local variables	Global variables
Declared inside function body	Declared outside function body
Not initialized automatically	Initialized automatically by value 0
Use of local variables advisable	Too much use of global variables make program difficult to debug, so use with care

Life time of a variable means what will be the life of a variable i.e when the variable will come in to existence and how long it will hold the value. For example, local variables have the lifetime till the control remains in that function. As soon as the control moves out of the function, local variables life is over i.e destroyed.

Storage class decides the scope and lifetime of a variable. There are four storage classes.

- Auto
  - o Life time till the control remains in that function.
- Register
  - o Life time till the control remains in that function.
- Static
  - o Life time is entire program execution with retaining values between function calls.
- External
  - o Life time is entire program execution.

Following program demonstrates use of static variable.

```
#include <stdio.h>
void fun1();
main()
  {
  int i;
  clrscr();
  for (i=1; i<=5; i++)
      fun1(); /* call function */
  }
  void fun1()
  {
  static int n=2; /* static variable initialized only once */
  n = n *2;
  printf("n = %d\n",n);
```

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```
}
```

It will produce output as shown below.

```
n = 4
n = 8
n = 16
n = 32
n = 64
```

14. Write a function using a pointer parameter that calculate maximum element from given array of integer numbers.

Ans:

```
#include<stdio.h>
int getmax(int *b,int n)    /* function body */
{
    int max;
    int i=1;
    max= *b;
    while (i<=n)
        {
        b++;
        if ( max  < *b)
        max= *b;
        i++;
        b++;
        }
    return max;
}
void main()
{
    int i;
    int a[100];
    int n, max;
    printf("How many numbers? \n");
    scanf("%d", &n);
    for(i=0;i<n;i++)
        {
        printf("\nGive number %d: ", i+1);
        scanf("%d", &a[i]);
        }
  max = getmax(a,n);  /*function call */
  printf("\nMaximum number is = %d\n",max);
}
```


: SHORT QUESTIONS :

1. In every 'C' program which function must be there?

⇒ In every 'C' program, main() function must be there.

2. List the types of functions.

⇒ Depending on who created the function, there are 2 type of functions: User defined functions, and Library functions.

3. Write the syntax for declaration of function.

⇒ The syntax is :

type function_name(arguments);

4. Is declaration of function compulsory?

⇒ No, it is not compulsory. Declaration of function is compulsory only when call to the function in the program comes before the definition of the function.

5. List the types of scope of a variable.

⇒ There are two types of scope of variable: local and global.

6. Which is the default storage specifier?

⇒ Default storage specifier is: auto.

7. What does static variable mean?

⇒ Static variables are the variables which retain their values between the function calls. They are initialized only once their scope is within the function in which they are defined.

8. What is the default initial value for a static variable?

⇒ Default initial value for a static variable is garbage value.

9. Can main() be called recursively?

⇒ Yes any function including main() can be called recursively.

❖

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Module-9

Structures and Unions

9.1 INTRODUCTION :

In previous chapters, we have used the basic data type as well as arrays. The basic data types and variables can store only one type of data. In real life, we find situations where we need to store data items that are logically related but contain different type of information which require different data types. For example, Student record is a collection of data items such as roll number, name, address, city, sex, age etc. which are dissimilar data items. Here, roll number is an integer type, name, address, city is array of characters, sex is a character type variable, and age is an integer. Similarly, Book is a collection of data items such as title, author name, publisher name, number of pages, price, year of publication etc. Here again, title, author name, publisher name are array of characters, while number of pages and year of publication is integer, while price can be float number. To handle the data of dissimilar type, which are logically related to each other, 'C' language provides a new data type called as structure.

9.2 WHAT IS STRUCTURE ?

Structure is a collection of logically related data items of different data types grouped together and known by a single name. So, we can say that structure is a group of variables of different types known by a single name. Structure is similar to records in DBMS. As record consists of fields, the data items of a structure are called as its members or fields.

Syntax for defining the structure is :

```
struct  struct_name
{
datatype  var1;
datatype  var2;
.
.
};
```

Here, the keyword struct is used to define a structure template. struct_name is an optional tag which provides a name of a structure. It is a user defined name. The members of the structure are written in Curly {} braces. The structure definition is terminated by semicolon (;) symbol. The struct_name can be used to declare variables of its type. So, effectively we are creating a user defined data type named as struct_name.

Example : For the Student, we can write the structure as shown below:

```
struct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    int  age;
};
```

Above definition declares a structure named as student, having 6 member variables. rollno and age are integers, while name, address, city are arrays, and sex is a character type variable. Writing only the declaration does not declare any structure variables. If we want to store data in the structure using above prototype, we need to declare variables of the structure type. The structure variables can be declared in different ways.

- Variable declaration with the template itself.
- Variable declaration any where in the program.
- Array of structures

Following example shows s1 and s2 as struct variables of student type with the template itself.

```
struct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    int  age;
} s1,s2;
```

Note that s1 and s2 are written immediately after } symbol and terminated by semicolon symbol. Following example shows s1 and s2 as struct variables of student type. The declaration can be anywhere in the program.

```
struct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    int  age;
};
.
.
.
struct  student  s1,s2;
```

Note that first the template is defined, and the variables are declared by the statement

```
struct  student  s1,s2;
```

This statement can appear at any place where we can declare variables of other types also.

9.3 ACCESSING STRUCTURE MEMBERS :

We can access the individual members of a structure using the dot (.) operator. The dot (.) operator is called as structure member operator because it connects the structure variable and its member variable.

The syntax is :

```
struct_var.struct_member;
```

where, struct_var is a variable of structure type, while struct_member is a name of a member variable of structure.

For example, for the struct student with s1 and s2 as variables,

```
s1.rollno =5;
```

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```
s1.age  =  20;
s2.rollno  =7;
s2.age  =  21;
s1.sex  =  'm';
s2.sex  =  'f';
```

Above code assigns student s1 rollno = 5, age = 20 and sex = 'm' while for student s2 rollno = 7, age =21 and sex ='f'.

Program :

```
/* Write a program to input and print following details of student using structure - roll number, name,
address, city, sex and age */

#include  <stdio.h>
#include  <conio.h>
void  main()
{
    struct  student          /*  structure  definition*/
    {
    int  rollno;
    char  name[20];
    char  address[30];
    char  city[20];
    char  sex;
    int  age;
    };
    struct  student  s1;   /*  structure  variable  */
    clrscr();
    printf("Give  roll  number\n");
    scanf("%d",&s1.rollno);        /* get roll number */
    fflush(stdin);                 /*  clear  buffer  */
    printf("Give  name\n");
    gets(s1.name);                 /*  get  name  */
    printf("Give  address\n");
    gets(s1.address);              /*  get  address  */
    printf("Give  city\n");
    gets(s1.city);                 /*  get  city  */
    printf("Give  sex\n");
    scanf("%c",&s1.sex);           /*  get  sex  */
    printf("Give  age\n");
    scanf("%d",&s1.age);           /*  get  age  */
    printf("Roll  Number  =  %d,  Name  =  %s,
```



```
    Address  =  %s\n",s1.rollno,  s1.name,  s1.address);
    printf("City  =  %s,  Sex  =  %c,  Age  =  %d\n",  s1.city,s1.sex,s1.age);
}
```

Output :

```
Give  roll  number
1
Give  name
vansh
Give  address
university  road
Give  city
patan
Give  sex
m
Give  age
3
Roll  Number  =  1,  Name  =  vansh,  Address  =  university  road
City  =  patan,  Sex  =  m,  Age  =  3
```

9.4 STRUCTURE INITIALIZATION :

As applicable to basic data types, we can also initialize the structure variable at the time of creation of variables. For our student structure example, it can be written as:

```
struct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    int  age;
};
.
.
struct  student  s1  =  {  1,  "Vansh",  "University
                           Road","Patan",'m',3};
struct  student  s2  =  {  2,  "Saniya",  "Krishna  Nagar",
                           "Ahmedabad",'f',4};
```

In above code, the two lines

```
struct  student  s1  =  {  1,  "Vansh",  "University
                           Road","Patan",'m',3};
struct  student  s2  =  {  2,  "Saniya",  "Krishna  Nagar",
                           "Ahmedabad",'f',4};
```

initializes the structure variables s1 and s2 with the values written in { } brackets.

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If all the values in initialization are not supplied, then rest of the member variables will be initialized to zero for numbers and NULL to strings. For example,

```
student s1 = { 1, "Vansh"};
```

will initialize only the rollno and name, while other variables are initialized to zero or NULL whichever is applicable.

Program :

```
/* Write a program to demonstrate initialization of structure members. */
#include <stdio.h>
#include <conio.h>
struct book
{
char title[25];
char author[20];
char publisher[20];
int pages;
float price;
};
void main()
{
struct book bk = { "C Programming", "XYZ","ABC Ltd",441,275};
clrscr();
printf("Title = %s, Author Name = %s\n", bk.title, bk.author);
printf("Publisher = %s\n",bk.publisher);
printf("Pages = %d, Price = %6.1f\n",bk.pages,bk.price);
}
```

Output :

```
Title = C Programming, Author Name = XYZ
Publisher = ABC Ltd
Pages = 441, Price = 275.0
```

9.5 ARRAY OF STRUCTURES :

As we have an array of basic data types, same way we can have an array variable of structure. For our student example, suppose we want to store details of 50 students, in stead of declaring 50 different variables of student type, we can declare an array of size 50 to store details of 50 students.

Following example shows how an array of structures can be declared.

```
struct student
{
    int rollno;
    char name[25];
    char address[30];
    char city[15];
```



```
    char sex;
    int age;
};
.
.
.
struct student s[50];
```

Above example, defines the student structure, and the line

```
struct student s[50];
```

declares an array s[50] of student type structure. We can access individual members of an array by using the subscript variable like s[0], s[1], s[2] etc.

Program :

```
/* Write a program to calculate net salary of N employees using structure.
Total = Basic + DA + HRA +TA,                    Net = Total - Itax
Itax = 5 % of Total ,DA = 50 % of Basic, HRA = 15 % of Basic TA = 400 fix  */
#include <stdio.h>
#include <conio.h>
struct employee
{
    char name[20];
    double basic;
    double da;
    double hra;
    double ta;
    double total;
    double net;
};
void main()
{
    struct employee emp[50];
    int i,n;
    double temp;
    clrscr();
    printf("How many employees ?\n");
    scanf("%d",&n);
    for(i=0;i<n;i++)
        {
        printf("Give name :");
        scanf("%s",emp[i].name);
```

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```
        printf("\nGive basic :");
        scanf("%lf",&temp);
        emp[i].basic = temp;
        emp[i].da = emp[i].basic *0.5;
        emp[i].hra = emp[i].basic *0.15;
        emp[i].ta = 400;
        emp[i].total = emp[i].basic + emp[i].da + emp[i].hra +emp[i].ta;
        emp[i].net = emp[i].total - emp[i].total * 0.05;
        }
    printf("Name Basic Da Hra Ta Total Net\n");
    for(i=0;i<n;i++)
    printf("%-10s %6.1f %6.1f %6.1f %6.1f %7.1f%7.1f\n",
    emp[i].name,emp[i].basic, emp[i].da,
    emp[i].hra,emp[i].ta,emp[i].total,emp[i].net);
}
```

Output :

```
How many employees ?
2
Giv name :sms
Give basic :12000
Give name :bvb
Give basic :18000
Name Basic Da Hra Ta Total Net
sms 12000.0 6000.0 1800.0 400.0 20200.0 19190.0
bvb 18000.0 9000.0 2700.0 400.0 30100.0 28595.0
```

Program :

/* Write a program to calculate average marks of N students for 3 different subjects using structures. */

```
#include <stdio.h>
#include <conio.h>
struct stud_exam
{
    char name[20];
    int m1;
    int m2;
    int m3;
    float avg;
};
void main()
{
```



```
    struct stud_exam st[50];
    int i,n;
    clrscr();
    printf("How many students ?\n");
    scanf("%d",&n);
    for(i=0;i<n;i++)
        {
        printf("Give name :");
        scanf("%s",st[i].name);
      printf("\nGive marks of subject 1, 2 and 3 :");
                scanf("%d%d%d",&st[i].m1,&st[i].m2,&st[i].m3);
      st[i].avg = (st[i].m1 + st[i].m2 + st[i].m3)/3;
      }
    printf("Name Subject1 Subject2 Subject3 Average\n");
    for(i=0;i<n;i++)
    printf("%-10s %7d %7d %7d %7.2f\n", st[i].name,
    st[i].m1,st[i].m2,st[i].m3,st[i].avg);
}
```

Output :

```
How many students ?
2
Give name :shrey
Give marks of subject 1, 2 and 3 :69 56 60
Give name :saniya
Give marks of subject 1, 2 and 3 :44 55 66
Name Subject1 Subject2 Subject3 Average
shrey 69 56 60 61.00
saniya 44 55 66 55.00
```

9.6 NESTED STRUCTURES :

When the member variable of a structure itself is a structure, it is called as nesting of structures. The structure which is nested inside other structure must be declared as a structure before the structure in which it is nested.

Suppose we want to include the birth date in stead of age in student structure, we can first define a structure for date as shown.

```
struct date
{
int day;
int month;
int year;
```

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```
};
stuct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    struct  date  bdate;
};
```

Here, in the definition of student structure, last member bdate itself is a structure of type date. The date structure is declared as having three parts namely: day, month and year.

If the date of birth is 1/1/1995, it can be written as

```
struct  student  s1;
s1.bdate.year  =  1995;
s1.bdate.month=1;
s1.bdate.day  =1;
```

In above declaration of date and student, we can declare variables of date as well as student type. But if the above definition is written as

```
stuct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    struct  date
    {
      int  day;
    int  month;
    int  year;
    }  bdate;
};
```

Then we can create variables of student type only. We can not create variables of date type. So; effectively date structure is not global data type, but it becomes local to student data type.

If we have declared the variable s1 as

struct student s1;

then we can access day by statement :

```
s1.bdate.day;
```


Program :

```
/* Write a program using nested structure to accept and print details of an employee. */
#include  <stdio.h>
#include  <conio.h>
struct  address
{
char  add1[30];
char  add2[30];
char  area[30];
char  city[20];
};
struct  employee
{
char  name[20];
struct  address  a;
int  sal;
};
main()
{
struct  employee  e;
clrscr();
printf("Give  name  :");
scanf("%s",e.name);
printf("Give  address  line1,  line2,  area  and  city  name\n");
gets(e.a.add1);
gets(e.a.add2);
gets(e.a.area);
gets(e.a.city);
printf("Give  salary\n");
scanf("%d",&e.sal);
printf("Details  of  employee:\n");
printf("Name  :  %s\n",e.name);
printf("Address  :");
printf("%s",e.a.add1);
printf("%s",e.a.add2);
printf("%s",e.a.area);
printf("%s",e.a.city);
printf("\nSalary  =  %d\n",e.sal);
}
```

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Output :

```
Give name :sanjay
Give address line1, line2, area and city name
a-2 ashish society
near railway station
unjha
Give salary
20000
Details of employee:
Name : sanjay
Address : a-2 ashish society,near railway station,unjha
Salary = 20000
```

9.7 STRUCTURE AND FUNCTIONS :

As we can pass a variable of basic data type and an array to function as an argument, same way we can pass the structure member as well as whole structure to the function.

When we want to process only the structure member, we pass only its value using structure variable and dot (.) operator and the name of member variable, but when we want to process the whole structure, we pass a structure variable as an argument.

For example,

If fun1() is to be called then calling fun1() as ,

fun1(s1.rollno); is an example of passing the structure member rollno only.

While the call,

fun1(s1); is an example of passing whole structure as an argument.

Program :

/* Write a program using function and structure to accept Item information such as name, quantity, unit price, and cost. Then print the details of each item. */

```
#include <stdio.h>
#include <conio.h>
struct item
{
char name[25];
int qty;
float price;
float cost;
};
float calculate(int q, float p)
    {
    return q*p;
    }
```



```
void print_items(struct item i)
    {
    printf("\n%-12s %5d %6.1f
            %6.1f\n",i.name,i.qty,i.price,i.cost);
}
main()
{
struct item it[20];
float temp;
int i,n;
clrscr();
printf("How many items ?" );
scanf(„%d",&n);
for(i=0;i<n;i++)
 {
 flushall();
 printf("Give name of item:");
 gets(it[i].name);
 //flushall();
 printf("Give quantity :");
 scanf("%d",&it[i].qty);
 printf("Give unit price:");
 scanf("%f",&temp);
 it[i].price = temp;
 it[i].cost = calculate(it[i].qty,it[i].price);
 }
 printf("\nName        Quantity    Price    Cost\n");
 for(i=0;i<n;i++)
     print_items(it[i]);
 }
```

Output :

```
How many items ?3
Give name of item:shampoo
Give quantity :30
Give unit price:45
```

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```
Give name of item:soap
Give quantity :35
Give unit price:13
Give name of item:hair oil
Give quantity :20
Give unit price:30
Name          Quantity    Price     Cost
shampoo         30        45.0     1350.0
soap            35        13.0      455.0
hair oil        20        30.0      600.0
```

9.8 POINTERS AND STRUCTURES :

For representing complex data structures, we can use structures and pointers together. Pointer can be a member of structure, or a pointer to a structure, or an array of pointers to structure.

We can declare a pointer to structure as we do for pointers to basic data types.

```
struct student
{
int rollno;
char name[20];
char address[30];
char city[20];
char sex;
int age;
} s1,*sptr;      /*Here, s1 is structure variable,
                 while sptr is a pointer to structure */


sptr = &s1;
/* assign address of struct variable s1 to sptr */
```

Now, sptr points to s1 and can be used to access member variables of struct student. To access member variables using pointer to structure, we have to use an arrow -> operator. The syntax is :

```
struct_pointer -> member_var;
```

the struct_pointer is a pointer to structure, and member_var is the name of member variable. For our example, we can use like this:

```
s1 -> rollno = 20;
```

We can also use . operator to access member variable with pointer to structure like:

```
(*s1).rollno = 20;
```

Both above statements do the same thing. But if we use dot (.) operator, then parenthesis is necessary because the dot (.) operator has higher precedence than * operator.

We can also use pointer to structure to create the structure dynamically using dynamic memory allocation. For example the statement,

```
sptr = (struct student *) malloc (sizeof (struct student));
```

allocates a one block of storage for student structure and stores the pointer to that in sptr variable. Similarly, we can write the statement,

```
sptr = (struct student *) malloc (10 * sizeof (struct student));
```


to allocate memory for array of 10 structures of student type and stores the address of first block to variable sptr.

We can use sptr in a loop using -> operator to access individual members of structure. When we write statement like

```
sptr++;
```

then it points to the next structure element.

For example, following for loop will get 10 values from keyboard and store it in structure array created dynamically.

```
for (i =0;i<10;i++)
    {
    printf("Give rollno and age of student\n");
          /* only rollno and age values shown */
    scanf("%d%d",&sptr->rollno, &sptr->age);
    sptr++;
    }
sptr = sptr -10;
/* point sptr back to first element in an array*/
```

Program :

```
/* Write a program to print the number with its cube using pointer to structure */
#include <stdio.h>
#include <conio.h>
struct cube
{
    int num;
    int c;
};
void main()
{
    struct cube *ptr;
    int i,n;
    clrscr();
    printf("How many numbers ?\n");
    scanf("%d",&n);
    ptr = (struct cube *)malloc (n * sizeof(struct cube));
    for(i=0;i<n;i++)
        {
        printf("Give number :");
        scanf("%d", &(ptr->num));
        ptr ->c = ptr -> num * ptr -> num *ptr -> num;
        ptr++;
        }
```

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```
    ptr = ptr -n;
    printf("Number   Cube\n");
    for(i=0;i<n;i++)
        {
        printf("%d\t  %d\n",ptr->num,ptr->c);
        ptr++;
        }
}
```

Output :

```
How many numbers ?
2
Give number :1
Give number :2
Number    Cube
  1        1
  2        8
```

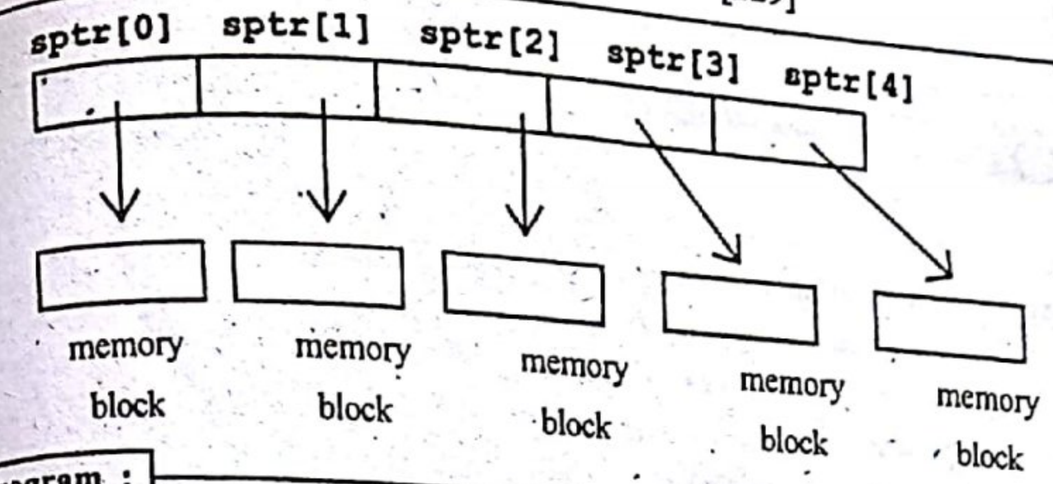
9.9 ARRAY OF POINTERS TO STRUCTURES :

If we declare an array of structures, then it occupies more memory. For example; if we take student structure defined earlier, we can find out the exact number of bytes required to store one structure data using sizeof() statement. Let us assume that it is 75 bytes. So, if we have an array of size 20 then total number of bytes required is 75 * 20 = 1500 bytes. At run-time if we have only 5 array elements, then the remaining bytes in memory are wastage. This wastage of memory can be avoided by using dynamic memory allocation, where we declare an array of pointers to structure in stead of array of structures.

For the student example,

```
struct student
{
int rollno;
char name[20];
char address[30];
char city[20];
char sex;
int age;
} *sptr[20];
```

declares an array of pointers to structure of size 20. In this case only memory required to store 20 pointer variables is used in stead of 20 structure elements. We can use dynamic memory allocation method to get a block of memory and assign its address to the individual members of array of pointers. Suppose we use only five student data then it will pictorially look like this.



Program :

```
/* Write a program to input and print details of students using array of pointers to structure. */
#include<stdio.h>
#include<conio.h>
#include<conio.h>
struct student
{
int rollno;
char name[20];
char address[30];
char city[20];
char sex;
int age;
}*st[20];          /* array of pointers to structures */
main()
{
int i,n;
clrscr();
printf("How many students? ");
scanf("%d",&n);
for(i=0;i<n;i++)
    {
    st[i] = (struct student *) malloc
     (sizeof(struct student)); /* get one block */
    printf("\nGive roll number : ");
            /* get data and store in structure */
    scanf("%d",&(st[i]->rollno));
    printf("\nGive student name : ");
    scanf("%s",st[i]->name);
    printf("\nGive address: ");
    scanf("%s",st[i]->address);
    printf("\nGive city: ");
    scanf("%s",st[i]->city);
    printf("\nSex? : ");
    scanf("%c",&(st[i]->sex));
```

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```
    printf("Age?  :");
    scanf("%d",&(st[i]->age));
    }
printf("Roll  No\tName    Address    City     Sex  Age\n");
for(i=0;i<n;i++)      /* print data */
    printf("%d\t%-15s\t%-15s\t%-15s\t%c\t%d\n",
    st[i]->rollno,st[i]->name,st[i]->address,
    st[i]->city,st[i]->sex,st[i]->age);
getch();
}
```

Output :

```
How many students? 2
Give roll number : 1
Give student name : paresh
Give address: rajmahel
Give city: mahesana
Sex? : m
Age? :20
Give roll number : 2
Give student name : sanket
Give address: Ullasnagar
Give city: mumbai
Sex? : m
Age? :21
Roll No    Name      Address     City      Sex    Age
  1        paresh    rajmahel    mahesana  m      20
  2        sanket    Ullasnagar  mumbai    m      21
```

9.10 UNION :

It is a user defined data type like structure. It also allows grouping of dissimilar data items by a single name. But, the difference is in their working. Structures occupy more memory because all the member variables occupy separate storage, while unions occupy less memory because all the member variables are not allocated separate storage but share a memory area between all the memory variables. So, unions allow storage of one member at a time.

The syntax for defining union is same as that for structure except that a keyword union is used in place of struct.

Syntax :

```
union  union_name
{
data_type  member1;
data_type  member2;
```



```
};
```

Example of union :

```
union  student
        {
        int  rollno;
        char  name[20];
        char  address[30];
        char  city[20];
        char  sex;
        int  age;
        }s1,s2;
```

We can get the address of a union variable by using & operator. We can also pass the union to function as an argument.

Program :

```
/* Program demonstrating union */
#include<stdio.h>
#include<conio.h>
union  uni
{
int  i;
char  c;
float  f;
}  u;
main()
{
clrscr();
u.i  =  5;
printf("Member  i  =  %d\n",u.i);
u.c  =  'a';
printf("Member  c  =  %d\n",u.c);
u.f  =  3.5;
printf("Member  f  =  %f\n",u.f);
printf("Following  printf  will  produce  wrong  value  of  i\n");
printf("because  i  member  is  not  active.  Currently  active  member  is
f\n");
printf("Member  i  =  %d\n",u.i);
getch();
}
```

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Output :

```
Member i = 5
Member c = 97
Member f = 3.500000
Following printf will produce wrong value of i
because i member is not active. Currently active member is f
Member i = 0
```

Following table shows important differences between structure and union.

Structure	Union
Each member has its own separate storage space	All members share the storage space
Memory occupied is the total required to store all the members	Memory occupied is only that much which is required to store the largest member of union
All members can be accessed any time	Only one member can be active at a time

Example:
struct employee
{
int empid;
char name[20];
int age;
float salary;
};
Total size required =
2 +20+2+4 = 28 bytes
	Example:
	Union employee
	{
	int empid;
	char name[20];
	int age;
	float salary;
	};
	Total memory required =
	max(2,20,2,4) = 20 bytes

The syntax and meaning for use of dot (.) operator and -> operator is same as in the case of structure.

Program :

```
/* Write a program to demonstrate the difference between structure and union*/
#include<stdio.h>
#include<conio.h>
union uni
{
int i;
char c;
float f;
} u;
struct stu
{
int i;
char c;
float f;
```



```
} s;
main()
{
int k;
clrscr();
k = sizeof(u);
printf("Total size required by union u is %d bytes\n",k);
k = sizeof(s);
printf("Total size required by structure s is %d bytes\n",k);
getch();
}
```

Output :

```
Total size required by union u is 4 bytes
Total size required by structure s is 7 bytes
```

9.11 SOLVED PROGRAMMING EXAMPLES :

Program :

```
/* Write a program to calculate and print total salary of employees using structure. Hra = 15% of basic,
Da = 50 % of basic, Ta = 5% of basic */
#include<stdio.h>
#include<conio.h>
struct employee
{
char name[20];
long int basic;
float da;
float hra;
float ta;
float total;
};
main()
{
struct employee *emp;
int i,n;
clrscr();
printf("How many employees\n");
scanf("%d",&n);
emp = (struct employee *) malloc(n*sizeof(struct employee));
```

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```
for(i=0;i<n;i++)
    {
    printf("\nGive employee name: ");
    scanf("%s",emp->name);
    printf("\nGive basic salary: ");
    scanf("%ld",&(emp->basic));
    emp->da = emp->basic * 0.5;
    emp ->hra = emp->basic * 0.15;
    emp-> ta = emp->basic * 0.05;
    emp->total = emp->basic + emp->da +emp->hra +emp->ta;
    emp++;
    }
emp = emp-n;
printf("Name\t\Basic\tDa\tHra\tDa\tTotal\n");
for(i=0;i<n;i++)
    {
    printf("%s\t%ld\t%6.0f\t%6.0f\t%6.0f\t%7.0f\n",
    emp->name,emp->basic,emp->da,emp->hra,emp->ta,
    emp->total);
    emp++;
    }
getch();
}
```

Output :

```
How many employees
3
Give employee name: Reena
Give basic salary: 12200
Give employee name: Ramesh
Give basic salary: 12400
Give employee name: Hari
Give basic salary: 10325
Name    Basic   Da    Hra   Da    Total
Reena   12200   6100  1830  610   20740
Ramesh  12400   6200  1860  620   21080
Hari    10325   5162  1549  516   17552
```


Program :

```
/* Write a program to store information about books and display those books which cost less than Rs.
300*/
#include <stdio.h>
#include<conio.h>
struct book
{
    char title[25];
    char author[20];
    char publisher[20];
    int pages;
    float price;
};
void main()
{
    struct book bk[20];
    int i,n;
    float temp;
    clrscr();
    printf("How many books?\n");
    scanf("%d",&n);
    for(i=0;i<n;i++)
        {
        flushall();
        printf("Give title of book: ");
        gets(bk[i].title);
        printf("Give author name: ");
        gets(bk[i].author);
        printf("Give publisher name: ");
        gets(bk[i].publisher);
        printf("Give pages: ");
        scanf("%d",&(bk[i].pages));
        printf("Give price: ");
        scanf("%f",&temp);
        bk[i].price = temp;
        }
    printf("\n\nBooks \n");
    for(i=0;i<n;i++)
        {
```

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```
        puts(bk[i].title);
        puts(bk[i].author);
        puts(bk[i].publisher);
        printf("pages = %d price = %5.1f\n", bk[i].pages,bk[i].price);
    }
printf("\n\nBooks costing < Rs. 300 \n");
for(i=0;i<n;i++)
    {
        if(bk[i].price < 300)
        {
        puts(bk[i].title);
        puts(bk[i].author);
        puts(bk[i].publisher);
        printf("pages = %d price = %5.1f\n\n",
        bk[i].pages,bk[i].price);
        }
    }
}
```

Output :

```
How many books?
3
Give title of book: C programming
Give author name: Herbert
Give publisher name: Mcgraw Hill
Give pages: 350
Give price: 200
Give title of book: Distributed O S
Give author name: Pradeep Sinha
Give publisher name: Prentice Hall
Give pages: 600
Give price: 350
Give title of book: Computer networks
Give author name: Forouzan
Give publisher name: Tata Mcgrawhill
Give pages: 450
Give price: 250

Books
C programming
Herbert
Mcgraw Hill
pages = 350 price = 200.0
```



```
Distributed O S
Pradeep Sinha
Prentice Hall
pages = 600 price = 350.0
Computer networks
Forouzan
Tata Mcgrawhill
pages = 450 price = 250.0

Books costing < Rs. 300
C programming
Herbert
Mcgraw Hill
pages = 350 price = 200.0
Computer networks
Forouzan
Tata Mcgrawhill
pages = 450 price = 250.0
```

: MCQs :

1. What is not TRUE about structures?
   (a) Collection of variables (b) variables must be of same type
   (c) variables can be different type (d) All of above
2. Structure and union are user defined data type
   (a) True (b) False
   (c) Structure only is user defined (d) Union only is user defined
3. It is legal to have structure variable as a member variable of other structure i.e structure within structure.
   (a) False (b) True
4. If we have
   struct student s1;
   to access member variables with s1 we use
   (a) . (b) -> (c) & (d) *
5. If we have
   struct student *sptr;
   to access member variables with s1 we use
   (a) . (b) -> (c) & (d) *
6. Which data type allows storage of only one data item?
   (a) Union (b) struct (c) Both and b
7. In which data type all the members are active?
   (a) Union (b) struct (c) Both a and b

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8. Structure can contain elements of the same data type
   (a) true (b) false
9. Which of the following operator is used to select a member of a structure variable
   (a) .(dot) (b) ,(comma) (c) : (colon) (d) ;(semicolon)
10. Which of the following is collection of a different data types?
   (a) String (b) Array (c) Structure (d) Files
11. With reference to structures, S1 -> S2 is syntactically correct if :
   (a) S1 and S2 are structure
   (b) S1 is pointer to structure and S2 is a member of structure
   (c) S1 is structure and S2 is pointer to structure
   (d) S2 is structure and S1 is pointer to structure
12. The link between member and variable in structure is established using:
   (a) Arrow operator (->) (b) Pointer operator (*)
   (c) Pointer operator (&) (d) Dot operator (.)
13. Compile time initialization of a structure variable must have:
   (a) Tag name with keyword struct
   (b) Name of variable to be declared
   (c) Terminating semicolon
   (d) All of above
14. Which of following is possible combination with structure?
   (a) Structure within structure (b) Arrays within structure
   (c) Structure and function (d) All of above
15. main()

```
{   struct class
    {
        int W, H;
    }stu = {60, 170};
    printf("%d   %d", stu.H, stu.W);
}
```

   (a) 60 60 (b) 60 170 (c) 170 60 (d) 170 170

: ANSWERS :

1.	(b)	2.	(a)	3.	(b)	4.	(a)	5.	(b)	6.	(a)	7.	(b)	
8.	(a)	9.	(a)	10.	(c)	11.	(b)	12.	(d)	13.	(d)	14.	(d)	15. (c)

: LONG QUESTIONS ANSWERS :

1. What is structure? Explain its syntax with suitable example.

Ans:

Structure is a collection of logically related data items of different data types grouped together and known by a single name.

Syntax for defining the structure is:

```
struct  struct_name
{
datatype  var1;
datatype  var2;
.
.
};
```

For the Student, we can write the structure as shown below:

```
struct  student
{
int  rollno;
char  name[25];
char  address[30];
char  city[15];
char  sex;
int  age;
};
struct  student  s1,s2;
```

2. Explain how the members of structure can be accessed.

Ans:

We can ac cess the individual members of a structure using the dot (.) operator. The dot (.) operator is called as structure member operator because it connects the structure variable and its member variable.

The syntax is:

```
struct_var.struct_member;
```

where, struct_var is a variable of structure type, while struct_member is a name of a member variable of structure.

```
struct  student
{
    int  rollno;
    char  name[25];
    char  address[30];
    char  city[15];
    char  sex;
    int  age;
```

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```
};
struct student s1,s2;
```

For above structure example, for the struct student with s1 and s2 as variables,

```
s1.rollno =5;
s1.age = 20;
s2.rollno =7;
s2.age = 21;
s1.sex = 'm';
s2.sex = 'f';
```

Above code assigns student s1, rollno = 5, age = 20 and sex = 'm' while for student s2, rollno = 7, age =21 and sex ='f'.

5. What is nested structure? Explain with suitable example.

Ans:

When the member of a structure itself is a structure, it is called as nesting of structure.

The structure which is nested inside other structure must be declared as a structure before the structure in which it is nested.

Following example shows **date structure** used inside **student structure.**

```
struct date
{
int day;
int month;
int year;
};
stuct student
{
    int rollno;
    char name[25];
    char address[30];
    char city[15];
    char sex;
    struct date bdate;
} ;
```

Here, in the definition of student structure, last member bdate itself is a structure of type date. The date structure is declared as having three parts namely: day, month and year.

Following 'C' program explains the use of nested structure

```
#include <stdio.h>
struct address
{
char add1[30];
char add2[30];
```



```
char area[30];
char city[20];
};
struct employee
{
char name[20];
struct address a;
int sal;
};
main()
{
struct employee e;
clrscr();
printf("Give name :");
scanf("%s",e.name);
printf("Give address line1, line2, area and city name\n");
gets(e.a.add1);
gets(e.a.add2);
gets(e.a.area);
gets(e.a.city);
printf("Give salary\n");
scanf("%d",&e.sal);
printf("Details of employee:\n");
printf("Name : %s\n",e.name);
printf("Address :");
printf(",%s",e.a.add1);
printf(",%s",e.a.add2);
printf(",%s",e.a.area);
printf(",%s",e.a.city);
printf("\nSalary = %d\n",e.sal);
}
```

8. What is union? How it differs from structure?

Ans:

Following table shows important differences between structure and union.

: SHORT QUESTIONS :

1. Which data type is used to group different data type but logically related with each other?

⇒ structure and union data types.

2. Which operator is used to access member variables of structure?

⇒ Dot (.) operator is used to access member variables of structure.

3. Which operator is used to access member variables of structure using pointer to structure?

⇒ Using pointer to structure, we use arrow -> operator to access member variables of structure.

❖

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Module-10

Pointers

We have used variables which store different types of values depending on its type. Pointer is a variable that stores the address of another variable within the memory. So, we can say that pointer is a special type of variable which store the address of another variable as its value.

10.1 WHY POINTERS ?

- It enhances the capability of the language in manipulating the data.
- It reduces the size of the program.
- It is used for creating data structures such as linked lists, trees, graphs etc.
- It is used to pass information between different functions in both directions.
- It increases the execution speed of the program.
- If used with array of strings, then it reduces the storage space requirement.
- It allows working with dynamic memory allocation.

10.2 CONCEPT OF POINTERS :

All the variables stored in memory occupy some storage space in main memory of computer. Each location in main memory of computer is having its address. Each location in memory stores one byte of data. Multi-byte data types like integer, float, double requires more than one byte of storage space. Character requires 1 byte; integer requires 2 bytes; float requires 4 bytes and double requires 8 bytes. The addresses are sequential starting from 0.

For example, int a=2;

The compiler will automatically allocate some memory for this variable **a**. So, location where the value of **a** is stored, is called as the address of variable **a**. If the variable **a** is stored at location 100, then we cay say that the address of variable **a** is 100, while the value of variable **a** is 2.

a	←	name of variable
2	←	value
100	←	Address of variable

Now, if the 100 value is stored in other variable, then that variable can be called as the pointer to variable **a**, because that variable will hold the address of variable **a** as its value.

ptr	←	name of variable
100	←	value
450	←	Address of variable

As shown in above figure, variable **ptr** holds value 100 (which is the address of variable **a**) and the **ptr** is stored at location 450. Here, we can say that **ptr** variable is a pointer to the variable **a**.

How to assign the address of variable to other variable ?

To access the memory address of variable, the operator & is used, which is called as the address operator. We can assign the address of variable **a** to another variable **ptr** using & operator as :

```
ptr = &a;
```

This statement will assign the address of a (which is 100 in above example) to variable **ptr**. Thus, **ptr** variable is a pointer to variable **a**.

How to access value of variable using pointer variable ?

We can access the value of variable **a**, through the pointer variable **ptr**. We need to use the operator * (called as derefencing operator or indirection operator). So, *ptr (i.e * operator before pointer variable), represents

variable **a** in above example, it effectively means that later in the program, variables **a** and ***ptr** represent same value (2 in above example). **We can use *ptr or a to refer to the value of variable a,** because **ptr** is the pointer to **a**.

10.3 POINTER DECLARATION :

We have seen that pointer is a variable which store the address of another variable. But, how to declare a pointer variable? In above example, we have seen that **ptr** is a pointer, because we have stored the address of variable **a**. But, we have not mentioned how ptr variable is declared.

Syntax for pointer declaration is :

```
data_type  *varname;
```

where data_type means pointer to which type of data, varname is the name of a variable, while * symbol before the name indicates that the variable is a pointer type variable.

For above example,

```
int  *ptr;
```

declaration is needed because **ptr** variable stores the address of variable **a** (which is integer). This declaration says that **ptr** variable can store the address of any integer variable.

The declaration,

float *fptr; means that fptr is a pointer which points to float type of variable,

char *cptr; means that cptr is a pointer which points to char type of variable.

Program :

```
/* Write a program to print the address of variable and its value */
#include<stdio.h>
#include<conio.h>
main()
{
char ch = 'a';
float fl = 30.5;
int i = 50;
clrscr();
printf("Name\t\tValue\t\tAddress\n");
printf("ch\t\t%c\t\t%X\n",ch,&ch);
printf("fl\t\t%f\t\t%X\n",fl,&fl);
printf("i\t\t%d\t\t%X\n",i,&i);
}
```

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Output :

```
Name        Value        Address
ch          a            FFF5
fl          30.500000    FFF0
i           50           FFEE
```

As in the case of variable declaration and initialization, we can also initialize pointer at the time of declaration. For example,

```
int n = 10;
int *iptr = &n;
```

The above code declares variable **n** with value 10 and pointer variable **Iptr** which is also initialized with the address of variable **n**.

Now, the statement, *iptr = 20; will make the value of n = 20.

Consider following code,

```
int a=10;
int *ptr1 = &a;      /* ptr1 points to a */
int *ptr2;
ptr2=ptr1;           /* ptr2 also points to a*/
a = a+1;             /* a=11 */
*ptr1  = *ptr1 +1;   /* a=12 */
*ptr2  = *ptr2 +1;   /* a=13 */
```

After above statements are executed value of a will be equal to 13. From above code it is very clear that a = *ptr1 = *ptr2.

Another important point is that pointer must be initialized before using it.

These concepts are used in following program.

Program :

```
/* Write a program to access the data using pointer variables*/
#include<stdio.h>
#include<conio.h>
main()
{
char ch = 'a';
float fl = 30.5;
int i = 50;
char *cptr;          /* declare pointers */
float *fptr;
int *iptr;
cptr = &ch; /* assign addresses, pointers initialized*/
```



```
fptr= &fl;
iptr = &i;
clrscr();
printf("Using variables\n\n");
printf("Name\t\tValue\t\tAddress\n");
printf("ch\t\t%c\t\t%X\n",ch,&ch);
printf("fl\t\t%f\t\t%X\n",fl,&fl);
printf("i\t\t%d\t\t%X\n",i,&i);
printf("\nUsing pointer variables\n\n");
printf("ch\t\t%c\t\t%X\n",*cptr,cptr);
                    /* access variable through pointers */
printf("fl\t\t%f\t\t%X\n",*fptr,fptr);
printf("i\t\t%d\t\t%X\n",*iptr,iptr);
*cptr = *cptr +1;    /* increment ch through pointer*/
*fptr = *fptr +1;   /* increment fl through pointer */
*iptr = *iptr +1;   /* increment i through pointer */
printf("\nAfter incrementing by 1 using pointer\n\n");
printf("ch\t\t%c\t\t%X\n",ch,&ch);
printf("fl\t\t%f\t\t%X\n",fl,&fl);
printf("i\t\t%d\t\t%X\n",i,&i);
}
```

Output :

```
Using variables
Name        Value        Address
ch          a            FFF5
fl          30.500000    FFF0
i           50           FFEE
Using pointer variables
ch          a            FFF5
fl          30.500000    FFF0
i           50           FFEE
After incrementing by 1 using pointer
ch          b            FFF5
fl          31.500000    FFF0
i           51           FFEE
```

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10.4 POINTER ARITHMETIC :

As pointer variables store the address value, which are numbers, we can do arithmetic operations on pointer variables.

Some valid arithmetic operations on pointers are :

- Increment
- Decrement
- Adding integer number to pointer variable
- Subtracting integer number from pointer variable
- Subtracting one pointer from other pointer if pointing to same array

But, following arithmetic operations are not valid

- Addition of two pointers
- Multiplication operation with any number
- Division operation with any number

Following table explains valid operations. **ptr** is a pointer type variable.

Operation	Expression	Initial	New value of ptr for			Meaning
			Character	Integer	Float	
Increment	ptr++;	100	101	102	104	Increment to next location of same type
Decrement	ptr--	100	99	98	96	Decrement to next location of same type
Adding integer number	ptr=ptr+5;	100	105	110	120	Points to 5 locations after current location of same data type
Subtracting integer number	ptr=ptr-3;	100	97	94	88	Points to 3 locations before current location of same data type
Subtraction of one pointer from another	ptr=ptr1-ptr2;	ptr1=105 ptr2=100	5	5	5	All pointers must point to the same array

Consider following code,

```
int a=10;
int *ptr1 = &a;          /* ptr1 points to a */
a = a+1;                 /* a=11 */
++*ptr1;   /* a=12, Here, bracket is not needed */
(*ptr1)++   /* a=13 Here, bracket is needed */
```

Here, ++ *ptr1; statement evaluation takes place as ++(*ptr1) i.e the content where ptr1 points is incremented by 1. But, (*ptr1)++; statement requires brackets, because ++ has higher precedence than * operator. If we forget to put brackets, pointer address will be incremented first, and then value at that new address will be referred.

If we execute following code fragment:

```
main()
{
        int a=3, b=5,c, *p,*q;
        p = &b; q=&a;
        c = *p % *q;
        ++ (*p);
        printf("%d %d\n" ,*p, *q);
        printf("\n %d %d ",c,b);
}
```

In above program,

Statement	Effect
int a=3, b=5,c, *p,*q; P = &b; q=&a;	a =3, b=5 p points to b and q points to a, so *p =b=5 and *q =a=3
C = *p % *q; ++ (*p);	c = 5% 3 = 2 *p = *p +1 =5 + 1 =6, so b becomes 6 (*p is other way of referring b)
printf("%d %d\n" ,*p, *q); printf("\n %d %d ",c,b);	prints 6 3 prints 2 6

So, final output of above code will be

6 3

2 6

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Program :

```
/* Write a program to demonstrate pointer arithmetic */
#include<stdio.h>
#include<conio.h>
main()
{
   char ch ='a', *cptr;
   float fl = 30.5 , *fptr;
   int i =50, *iptr;
   clrscr();
   cptr = &ch;
   fptr = &fl;
   iptr = &i;
   printf("\nchar   floatint\n");
   printf("%x  %x   %x\n",cptr,fptr,iptr);
   cptr++;        /* increment pinters*/
   fptr++;
   iptr++;
   printf("\nAfter increment operation");
   printf("\nchar   floatint\n");
   printf("%x  %x   %x\n",cptr,fptr,iptr);
   cptr--;        /*decrement pointers */
   fptr--;
   iptr--;
   printf("\nAfter decrement operation");
   printf("\nchar   floatint\n");
   printf("%x  %x   %x\n",cptr,fptr,iptr);
   cptr = cptr +2;   /* addition by number 2*/
   fptr = fptr +2;
   iptr = iptr +2;
   printf("\nAfter adding by number 2");
   printf("\nchar   floatint\n");
   printf("%x  %x   %x\n",cptr,fptr,iptr);
   cptr = cptr -4;   /*subtract by number 4 */
   fptr = fptr -4;
   iptr = iptr -4;
   printf("\nAfter decrementing by number 4");
   printf("\nchar   floatint\n");
   printf("%x  %x   %x\n",cptr,fptr,iptr);
}
```


Output :

```
char      float     int
fff5      fff0      ffee
After increment operation
char      float     int
fff6      fff4      fff0
After decrement operation
char      float     int
fff5      fff0      ffee
After adding by number 2
char      float     int
fff7      fff8      fff2
After decrementing by number 4
char      float     int
fff3      ffe8      ffea
```

Comparison of pointers :

In an expression involving pointers, relational operators can be used if the pointer variables belong to same data type.

Example,

```
int *ptr1, *ptr2;
```

then expression if (ptr1 > ptr2) is valid because both pointers point to same data type.

Normally, comparison of pointers is useful when we are dealing with pointers which point to the different elements of the same array.

10.5 POINTER TO POINTER :

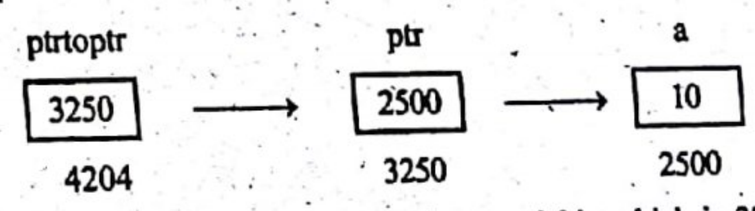
As the name suggests it is a pointer variable, which stores the address of another pointer variable. This type of variable can be declared using the syntax:

data_type **ptrtoptr; where ** indicates that variable named ptrtoptr is a pointer to pointer of data_type.

Example,

```
int a =10;
int * ptr= &a;
int **ptrtoptr;
ptrtoptr = &ptr;
```

above code explains the following relationship between variables in memory.



Here, **ptrtoptr** variable stores the address of **ptr** variable which is 3250, while **ptr** variable stores the address of variable **a**, which is 2500.

*ptrtoptr = ptr and *ptr =a. So, **ptrtoptr =a.

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Program :

```
/* Write a program to demonstrate pointer to pointer arithmetic. */
#include<stdio.h>
#include<conio.h>
main()
{
    int i = 50, *iptr, **iptrtoptr;
    clrscr();
    iptr = &i;          /* address of i in iptr */
    iptrtoptr = &iptr;
                /* address of iptr in iptrroptr */
    printf("iptrtoptr\t\tiptr\ti\n");
    printf("%d\t\t%d\t%d\n",**iptrtoptr,*iptr,i);
                        /* print values */
    printf("%x\t\t%x\t%x\n",&iptrtoptr,&iptr,&i);
                        /* print addresses */
}
```

Output :

```
iptrtoptr    iptr     i
   50         50      50
   fff0       fff2    fff4
```

10.6 POINTERS AND ARRAYS :

Pointers and arrays are very much related. When we studied array, at that time we did not mention about pointers. But, every program written using arrays can always be written using pointers. As we have seen that pointers make our program small and faster but too much use of pointer complicates the program to understand and debug. As was mentioned in the chapter on strings and arrays, the name of the array variable itself works as the address of array. By address of an array, we mean the address of the first element of the array.

Consider following declaration of an array :

```
int  a[5];
```

Here, the array name **a** works as an address of first element a[0]. The subscripted variable a[i] is internally represented using a pointer as *(a+i) by 'C' language. This is an example of pointer arithmetic, where a is the pointer variable and i is some integer number.

This can be shown pictorially as below.

a[0] or *(a+0)	100
a[1] or *(a+1)	102
a[2] or *(a+2)	104
a[3] or *(a+3)	106
a[4] or *(a+4)	108

In above figure, the address of array i.e address of first element a[0] is assumed as 100. Each integer occupies 2 bytes, so a[0] is at 100, a[1] is at location 102 and like that.

One point to remember about the name of an array is that it works as a pointer to first element of an array, but it is a constant pointer i.e its value can not be changed. So, we can not assign any other variables address to array name, a in our example. It also means that pointer arithmetic can not be done with array name.

So, if we want to access the individual elements of an array using pointer, we need to declare a pointer variable in the program, and we can do all the valid arithmetic operations on it.

Following program explains how we can access individual elements of an array using pointer variable.

Program :

```
/* Write a program to access array elements using pointer. */
#include<stdio.h>
#include<conio.h>
main()
{
    int a[10],i,n;
    int *ptr;
    clrscr();
    ptr =a;
    /* initialize ptr to start address of array  a*/
    printf("How many numbers?\n");
    scanf("%d",&n);
    printf("Give numbers\n");
    for(i=0;i<n;i++)
    {
    scanf("%d",ptr);
    ptr++;    /* go to next location in array */
    }
    ptr =a; /* initialize ptr to start address of array a*/
    printf("Array elements are:\n");
    for(i=0;i<n;i++)
        {
        printf("%d\n",*ptr); /* print array element */
        ptr++; /* go to next location in array */
        }
}
```

Output :

```
How many numbers?
4
Give numbers
1
2
```

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```
4
3
Array elements are:
1
2
4
3
```

Above program can also be written as below, where a[i] = *(a+i) concept is used.

Program :

```
/* Write a program to print array elements in reverse using pointer.*
#include<stdio.h>
main()
{
        int a[10],i,n;
        int *ptr;
        clrscr();
        ptr =a;
        printf("How many numbers?\n");
        scanf("%d",&n);
        printf("Give numbers\n");
        for(i=0;i<n;i++)
        {
            scanf("%d",ptr);
            ptr++;
        }
        ptr =a+n-1;
            /*points to the last element of array */
        printf("Array elements in reverse are:\n");
        while (ptr >= a)
        {
            printf("%d\n",*ptr);
            ptr--;
        }
}
```

Output :

```
How many numbers?
5
Give numbers
23
12
```



```
44
55
343
Array elements in reverse are:
343
55
44
12
23
```

Program :

```
/* Write a program to access array elements using pointer. */
#include<stdio.h>
#include<conio.h>
main()
{
    int a[10],i,n;
    clrscr();
    printf("How many numbers?\n");
    scanf("%d",&n);
    printf("Give numbers\n");
    for(i=0;i<n;i++)
        {
        scanf("%d",(a+i));
        }
    printf("Array elements are:\n");
    for(i=0;i<n;i++)
        {
        printf("%d\n",*(a+i));
        }
}
```

Output :

```
How many numbers?
4
Give numbers
1
2
4
3
Array elements are:
1
2
4
3
```

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10.7 ARRAY OF POINTERS :

As we have an array of char, int, float etc, same way we can have an array of pointers, individual elements of an array will store the address values. So, array of pointers is a collection of pointers of same type known by single name.

Syntax is :

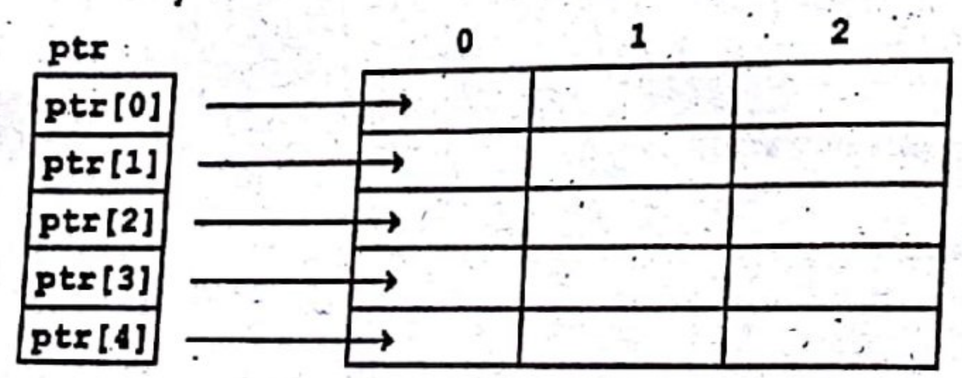
```
data_type  *name[size];
```

Example :

```
int *ptr[5]; declares an array of integer pointers of size 5
int mat[5][3]; declares a matrix of 5 rows and 3 columns
```

Now, the array of pointers ptr can be used to point to different rows of matrix as follow

```
for(i=0;i<5;i++)
    {
     ptr[i] = &mat[i][0];
    }
```



As stated above, by using dynamic memory allocation, we do not require to declare two-dimensional array, it can be created dynamically using array of pointers.

10.8 POINTERS AND STRINGS :

As we have studied in earlier chapter, string is a sequence of characters. It is a single dimensional array of characters. We can use pointers in string processing operations. Following program explain the use of pointers to manipulate strings.

Program :

```
/* Write a program to manipulate string using pointers. */
#include<stdio.h>
main()
{
    char str[20];
    int i,n,count=0;
    char *cptr;
    clrscr();
    printf("Enter some string\n");
    gets(str);              /* get string */
    cptr = str;
```



```
    /* cptr now points to first character of string */
    while(*cptr != '\0')  /* count length of string */
    {
        count++;
        cptr++;
    }
    printf("Length of string %s is = %d\n",str,count);
    cptr--;     /* set cptr to last character of
                   string from NULL character */
    printf("reverse of string %s is ",str);
    while(count >0)
    {
        putchar(*cptr);
        /* print from last to first character */
        count--;
        cptr--;
    }
}
```

Output :

```
Enter some string
Programming
Length of string Programming is = 11
reverse of string Programming is gnimmargorP
```

We can process an array of strings using dynamic memory allocation and array of pointers; we will study it in detail in the chapter on functions.

: MCQs :

1. Which operation is invalid for pointers?
   (a) Addition of two pointers (b) Increment
   (c) Decrement (d) Adding integer value to pointer variable
2. If ptr is a pointer to int, having value ptr =100. After ptr++, what is the value of ptr ?
   (a) 100 (b) 101 (c) 102 (d) 104
3. Which operator retrieves lvalue of a variable?
   (a) * (b) & (c) -> (d) None of above
4. For declaration of pointer variable, we use operator
   (a) * (b) -> (c) . (d) &
5. If array is declared as int a[5], then *(a+3) refers to
   (a) a[1] (b) a[2] (c) a[3] (d) None of above
6. The declaration int *a[5] means
   (a) Array of 5 integers (b) pointer to integers
   (c) Both a and b (d) Array of 5 pointers to integer

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7. Pointers can be used to create complex data structures like
   (a) Stack (b) Queue (c) Linked list and trees (d) All of above
8. A pointer value refers to
   (a) A float value (b) An integer constant
   (c) Any valid address in memory (d) None of above
9. A pointer is
   (a) a keyword used to create variables
   (b) a variable that stores the address of an instruction.
   (c) a variable that stores address of other variable.
   (d) All of above
10. Prior to using pointer variable:
   (a) It should be declared (b) It should be initialized
   (c) It should be both declared & initialized (d) None of these
11. Comment on this pointer declaration:
   int *X, Y;
   (a) X is pointer to integer, Y is not. (b) X & Y both are pointer to integer.
   (c) X is pointer to integer, Y may or may not be (d) X & Y both are not pointer to integer.
12. Which one of following is valid to access the address of variable A using pointer P?
   (a) P = *A (b) P = &A (c) P = &&A (d) P = A
13. If M and N are pointers then which one of following is valid?
   (a) M + 3 (b) M / N (c) N / 3 (d) M * N
14. Pointers reduce length and complexity of programs.
   (a) True (b) False (c) Can't say
15. P1 and P2 are pointer variables. Which is an illegal pointer expression?
   (a) P1++ (b) P2 + P1 (c) P1 – P2 (d) P2 > P1
16. Local variables in C are stored in memory which is known as:
   (a) Heap (b) Permanent storage area
   (c) ROM (d) Stack
17. main( )

```
{   int C=99, *ptr;
    ptr = &C;
printf("%d %u %u", *ptr, ptr, &C);  }
```

   (a) 99 3500 3502 (b) 66 3500 3502 (c) 99 3502 3502 (d) 66 3502 3502
18. main( )

```
{   int x[ ]={22, 33};
    int *p=x;
    printf("%d   %d ", ++*p,*p);
}
```

   (a) 33 22 (b) 22 33 (c) 22 23 (d) 23 22

: ANSWERS :

1. (a)	**2.** (c)	**3.** (b)	**4.** (a)	**5.** (c)	**6.** (d)	**7.** (d)
8. (c)	**9.** (c)	**10.** (c)	**11.** (a)	**12.** (b)	**13.** (a)	**14.** (c)
15. (d)	**16.** (a)	**17.** (c)	**18.** (d)			

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