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Department of Computer Science and Engineering

PRINCIPLES OF PROGRAMMING USING C

(BPOPS103/203)

MODULE 1-INTRODUCTION TO C

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CHAPTER 1

WHAT IS COMPUTER?

Computer can be defined as an electronic device that is designed to accept data, perform the required mathematical and logical operations at high speed and output the result.

1.1 GENERATION OFCOMPUTERS

The first electronic computer was designed and built at the University of Pennsylvania based on vacuum tube technology. Vacuum tubes were used to perform logic operations and to store data. Generations of computers has been divided into five according to the development of technologies used to fabricate the processors, memories and I/O units.

I Generation : 1945 –55

II Generation : 1955 –65

III Generation : 1965 –75

IV Generation : 1975 –89

V Generation : 1989 topresent

First Generation (ENIAC - Electronic Numerical Integrator And Calculator EDSAC – Electronic Delay Storage Automatic Calculator EDVAC – Electronic Discrete Variable Automatic Computer UNIVAC – Universal Automatic Computer IBM 701)

- Vacuum tubes were used – basic arithmetic operations took fewmilliseconds
- Bulky
- Consume more power with limitedperformance
- High cost
- Uses assembly language – to prepare programs. These were translated into machine level language for execution.
- Mercury delay line memories and Electrostatic memories wereused
- Fixed point arithmetic wasused
- 100 to 1000 fold increase in speed relative to the earlier mechanical and relay based electromechanicaltechnology
- Punched cards and paper tape were invented to feed programs and data and to getresults.
- Magnetic tape / magnetic drum were used as secondarymemory
- Mainly used for scientificcomputations.

Second Generation (Manufacturers – IBM 7030, Digital Data Corporation's PDP 1/5/8 Honeywell 400)

- Transistors were used in place of vacuum tubes. (invented at AT&T Bell lab in1947)
- Small insize
- Lesser power consumption and betterperformance
- Lower cost
- Magnetic ferrite core memories were used as main memory which is a random-access nonvolatilememory
- Magnetic tapes and magnetic disks were used as secondarymemory
- Hardware for floating point arithmetic operations wasdeveloped.
- Index registers were introduced which increased flexibility ofprogramming.
- High level languages such as FORTRAN, COBOL etc were used - Compilers were developed to translate the high-level program into corresponding assembly language program which was then translated into machinelanguage.
- Separate input-output processors were developed that could operate in parallel withCPU.
- Punched cards continued during this periodalso.
- 1000 fold increase in speed.
- Increasingly used in business, industry and commercial organizations for preparation of payroll, inventory control, marketing, production planning, research, scientific &engineering analysis and designetc.

Third Generation (System 360 Mainframe from IBM, PDP-8 Mini Computer from Digital Equipment Corporation)

- ICs wereused
- Small Scale Integration and Medium Scale Integration technology were implemented in CPU, I/O processorsetc.
- Smaller & betterperformance
- Comparatively lessercost
- Fasterprocessors
- In the beginning magnetic core memories were used. Later they were replaced by semiconductor memories (RAM &ROM)
- Introducedmicroprogramming
- Microprogramming, parallel processing (pipelining, multiprocessor system etc),

multiprogramming, multi-user system (time shared system) etc wereintroduced.

- Operating system software were introduced (efficient sharing of a computer system by several userprograms)
- Cache and virtual memories were introduced (Cache memory makes the main memory appear faster than it really is. Virtual memory makes it appearlarger)
- High level languages were standardized by ANSI eg. ANSI FORTRAN, ANSI COBOLetc
- Database management, multi-user application, online systems like closed loop process control, airline reservation, interactive query systems, automatic industrial control etc emerged during thisperiod.

Fourth Generation (Intel's 8088,80286,80386,80486 .., Motorola's 68000, 68030, 68040, Apple II, CRAY I/2/X/MP etc)

- Microprocessors were introduced as CPU– Complete processors and large section of main memory could be implemented in a singlechip
- Tens of thousands of transistors can be placed in a single chip (VLSI designimplemented)
- CRT screen, laser & ink jet printers, scanners etc weredeveloped.
- Semiconductor memory chips were used as the mainmemory.
- Secondary memory was composed of hard disks – Floppy disks & magnetic tapes were used for backupmemory
- Parallelism, pipelining cache memory and virtual memory were applied in a betterway
- LAN and WANS were developed (where desktop work stations interconnected)
- Introduced C language and UnixOS
- Introduced Graphical UserInterface
- Less powerconsumption
- High performance, lower cost and verycompact
- Much increase in the speed of operation

Fifth Generation (IBM notebooks, Pentium PCs-Pentium 1/2/3/4/Dual core/Quad core.. SUN work stations, Origin 2000, PARAM 10000, IBMSP/2)

- Generation number beyond IV, have been used occasionally to describe some current computer system that have a dominant organizational or application drivenfeature.
- Computers based on artificial intelligence areavailable
- Computers use extensive parallel processing, multiple pipelines, multiple processorsetc
- Massive parallel machines and extensively distributed system connected by communication networks fall in this category.

- Introduced ULSI (Ultra Large Scale Integration) technology – Intel's Pentium 4 microprocessor contains 55 million transistors millions of components on a single ICchip.
- Superscalar processors, Vector processors, SIMD processors, 32 bit micro controllers and embedded processors, Digital Signal Processors (DSP) etc have beendeveloped.
- Memory chips up to 1 GB, hard disk drives up to 180 GB and optical disks up to 27 GB are available (still the capacity isincreasing)
- Object oriented language like JAVA suitable for internet programming has beendeveloped.
- Portable note book computersintroduced
- Storage technology advanced – large main memory and disk storageavailable
- Introduced World Wide Web. (and other existing applications like e-mail, e Commerce, Virtual libraries/Classrooms, multimedia applicationsetc.)
- New operating systems developed – Windows 95/98/XP/…, LINUX,etc.
- Got hot pluggable features – which enable a failed component to be replaced with a new one without the need to shutdown the system, allowing the uptime of the system to be very high.
- The recent development in the application of internet is the Grid technology which is still in its upcomingstage.
- Quantum mechanism and nanotechnology will radically change the phase ofcomputers.

1.2 TYPES OFCOMPUTERS

Computer can be classified into four categories based on their speed,amount of data that they can hold and price.These categories are as follows

1. SuperComputers
2. Main FrameComputers
3. MiniComputers
4. MicroComputers

1. SuperComputers E.g.:- CRAY Research :- CRAY-1 & CRAY-2, Fujitsu (VP2000), Hitachi (S820), NEC (SX20), PARAM 10000 by C-DAC, Anupam by BARC, PACE Series by DRDO

- Most powerful Computer system - needs a largeroom
- Minimum world length is 64bits
- CPU speed: 100 MIPS

- Equivalent to 4000 computers
- High cost: 4 – 5millions
- Able to handle large amount ofdata
- High powerconsumption
- High precision
- Large and fast memory (Primary andSecondary)
- Uses multiprocessing and parallelprocessing
- Supportsmultiprogramming

Applications

- In petroleum industry - to analyze volumes of seismic data which are gathered during oil seeking explorations to identify areas where there is possibility of getting petroleum products inside theearth
- In Aerospace industry - to simulate airflow around an aircraft at different speeds and altitude. This helps in producing an effective aerodynamic design for superiorperformance
- In Automobile industry – to do crash simulation of the design of an automobile before it is released for manufacturing – for better automobiledesign
- In structural mechanics – to solve complex structural engineering problems to ensure safety, reliability and cost effectiveness. Eg. Designer of a large bridge has to ensure that the bridge must be proper in various atmospheric conditions and pressures from wind, velocity etc and under loadconditions.
- Meteorological centers use super computers for weatherforecasting
- In Biomedical research – atomic nuclear and plasma analysis – to study the structure of viruses such as that causingAIDS
- For weapons research and development, sending rockets to spaceetc

2. MainFrameComputers

E.g.**:-** IBM 3000 series, Burroughs B7900, Univac 1180,DEC

- Able to process large amount of data at very highspeed
- Supports multi-userfacility
- Number of processors varies from one tosix.
- Cost: 3500 to many milliondollars
- Kept in air conditioned room to keep themcool
- Supports many I/O and auxiliary storagedevices
- Supports network ofterminals

Applications

- Used to process large amount of data at very high speed such as in the case of Banks/ Insurance Companies/ Hospitals/ Railways…which need online processing of large number of transactions and requires massive data storage and processingcapabilities
- Used as controlling nodes in WANs (Wide AreaNetworks)
- Used to mange large centralizeddatabases

3. MiniComputers

E.g.:- Digital Equipments PDP 11/45 and VAX11)

- Perform better thanmicros
- Large in size and costlier thanmicros
- Designed to support more than one user at atime
- Posses large storage capacities and operates at higherspeed
- Support faster peripheral devices like high speedprinters
- Can also communicate with mainframes

Applications

- These computers are used when the volume of processing is large for e.g. Data processing for a medium sizedorganization
- Used to control and monitor productionprocesses
- To analyze results of experiments inlaboratories
- Used as servers in LANs (Local AreaNetworks)

4. MicroComputers

E.g.:- IBM PC, PS/2 and AppleMacintosh

- A microcomputer uses a microprocessor as its central Processing Unit. Microcomputers are tiny computers that can vary in size from a single chip to the size of a desktopmodel
- They are designed to be used by only one person at atime
- Small to medium data storage capacities 500MB –2GB
- The common examples of microcomputers are chips used in washing machines, TVs, Cars and Note book/Personalcomputers.

Applications

Used in the field of desktop publishing, accounting, statistical analysis, graphic designing, investment analysis, project management, teaching, entertainment etc

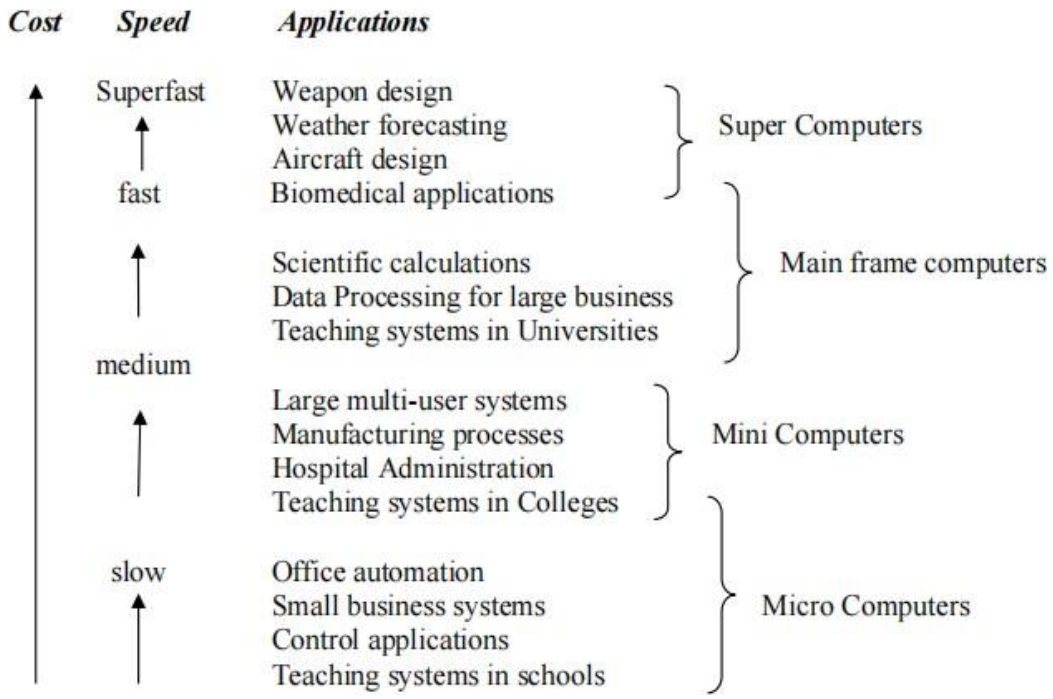
- The different models of microcomputers are givenbelow:-

a) **Personal computers**:- The name PC was given by the IBM for its microcomputers. PCs are used for word processing, spreadsheet calculations, database managementetc.

b) **Note book or Lap Top**:- Very small in terms of size – can be folded and carried around – Monitor is made up of LCD and the keyboard and system units are contained in a single box. Got all the facilities of a personal computer (HDD, CDD, Sound card, N/W card, Modem etc) and a special connection to connect to the desktop PC which can be used to transferdata.

c) **Palm Top**:- Smaller model of the microcomputer- size is similar to that of a calculator – pocket size- It has a processor and memory and a special connection to connect to the desktop PC which can be used to transferdata.

d) **Wrist PC**:- Smallest type of microcomputer – can be worn on our wrist like a watch- It has a processor and memory and a wirelessmodem



1.3 FUNCTIONAL UNITS OF A COMPUTER

Computer is a device that operates upon information or data. It is an electronic device which accepts input data, stores the data, does arithmetic and logic operation and outputs the information in desired format.

Even though the size, shape, performance, reliability and cost of computers have been changing over the years, the basic logical structure proposed by Von Neumann has not change. The internal architecture of computers differs from one system model to another. A block diagram of the basic computer organization specifying different functional units is shown below. Here the solid lines indicate the flow of instruction and data and the dotted lines represent the control exercised by the control unit.

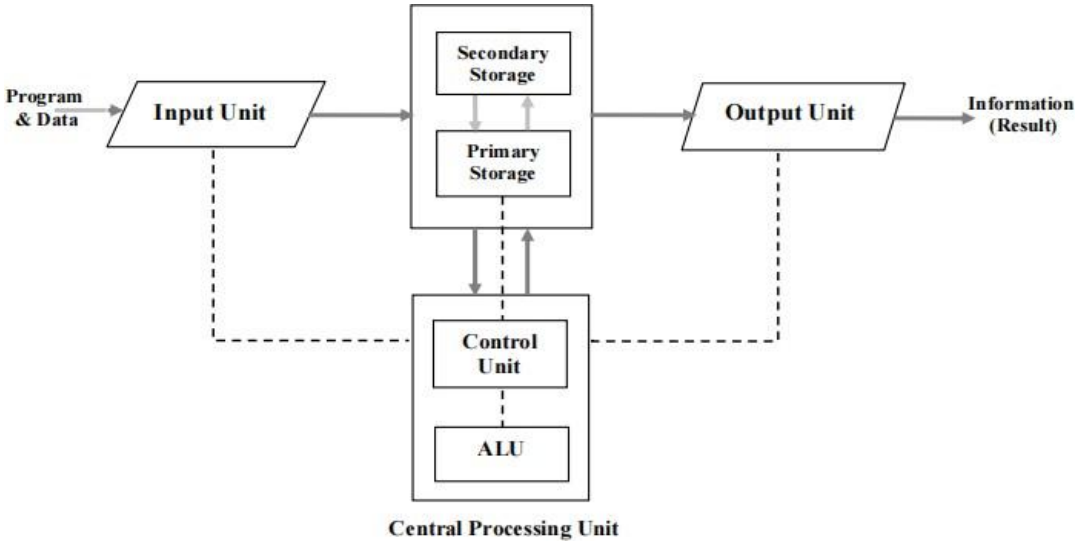


Figure 1- Block diagram of a computer

1.3.1 INPUT UNIT

Input unit accepts coded information from human operators through electromechanical devices such as the keyboard or from other computers over digital communication lines. The information received is either stored in the memory for later reference or immediately used by the Arithmetic and Logic circuitry to perform the desired operation. Finally the result is sent back to the outside through the output unit.

The keyboard is wired so that whenever a key is pressed, the corresponding letter or digit is automatically translated into its corresponding code and sent directly to either the memory or the processor.

Other kinds of input devices: Joy stick, track ball, mouse (pointing devices), scanner etc.

1.3.2 MEMORY UNIT

The memory unit stores program and data. There are two classes of memory devices :- Primary memory and Secondary memory.

1. Primary memory (Main memory)

- Contains a large number of semiconductor cells each capable of storing one bit of information
- These cells are processed in group of fixed size called words containing 'n' bits. The main memory is organized such that the contents of one word can be stored or retrieved in one basic operation.
- For accessing data, a distinct address is associated with each wordlocation.
- Data and programs must be in the primary memory forexecution.
- Number of bits in each word is called the word length and it may vary from 16 to 64bits.
- Fastmemory
- Expensive
- Time required to access one word is called Memory Access Time - 10nS to 100nS. This time is fixed and independent of thelocation.

E g. Random Access Memory (RAM)

2. Secondary storage

- They are used when large amount of data have to be stored (also when frequent access is not necessary)

E.g. Hard Disk, Compact Disk, Floppy Disk, Magnetic Tapes etc.

1.3.3 PROCESSOR UNIT

- The heart of the computer system is the Processorunit.
- It consists of Arithmetic and Logic Unit and ControlUnit.

Arithmetic and Logic Unit (ALU)

- Most computer operations (Arithmetical and logical) are executed in ALU of theprocessor.
- For example: Suppose two numbers (operands) located in the main memory are to be added. These operands are brought into arithmetic unit – actual addition is carried. The result is then stored in the memory or retained in the processor itself for immediateuse.

- Note that all operands may not reside in the main memory. Processor contains a number of high speed storage elements called Registers, which may be used for temporary storage of frequently used operands. Each register can store one word ofdata.
- Access times to registers are 5 to 10 times faster than access time tomemory.

Control Unit

- The operations of all the units are coordinated by the control unity (act as the nerve centre that sends control signal to other units)
- Timing signal that governs the I/O transfers are generated by the ControlUnit.
- Synchronization signals are also generated by the ControlUnit
- By selecting, interpreting and executing the program instructions the program instructions the control unit is able to maintain order and direct the operation of the entiresystem.

The control unit and ALU's are usually many times faster than other devices connected to a computer system. This enabled a single processor to control a number of external devices such as video terminals, magnetic taped, disk memories, sensors, displays and mechanical controllers which are much slower than theprocessor.

1.3.4 OUTPUT UNIT

- Counter part of input unit
- Output devices accept binary data from the computer - decodes it into original form and supplies this result to the outsideworld.

E.g. Printer, Video terminals (provides both input & output functions), graphic displays etc

Basic Operational Concepts:-

- Activity in a computer is governed byinstructions
- To perform a given task, a set of instructions called program must be there in the main memory
- Individual instructions are brought from the memory into the processor which executes the specific operation.
- Data to be used as operands are also stored in thememory.

E.g. **Add LOCA, R_0**

This instruction adds the operand at the memory location LOCA to the operand in the Processor R_0 and places the sum into the register R_0. Here the original contents of LOCA are preserved whereas those of R_0 are overwritten.

Steps:-

1. Instruction is fetched from the main memory intotheprocessor } ***Memory access operation***
2. Operand at LOCAisfetched
3. Add the contents to the contentsofR_0 } ***ALUoperation***
4. Finally store the result in R_0

Note: Data transfer between the main memory and the processor are started by sending the address of the memory location to be accessed to the memory unit and issuing the appropriate control signal by the control unit.

1.4 INTERNAL ORGANIZATION OF PROCESSOR

Processor contains a number of registers used for temporary storage of data other than ALU and Control circuitry

Instruction Register (IR) – holds the instruction that is currently being executed – its output is available to the control circuits which generate the timing signals that control the various processing elements involved in executing theinstruction.

Program Counter (PC) – It contains the address of the instruction currently being executed. During the execution of an instruction, the contents of the program counter are updated to hold the address of the next instruction to be executed. *i.e.* PC points to the next instruction that is to be fetched from thememory.

n General Purpose Registers (R_0 to R_{n-1}) – Facilitates communication with the main memory. Access to data in these registers is much faster than to data stored in memory locations because the registers are inside the processor. Most modern computers have 8 to 32 general purpose registers.

Memory Address Register (MAR) – holds the address of the location to or from which data are to be transferred

Memory Data Register (MDR) – contains the data to be written into or read out of the address location.

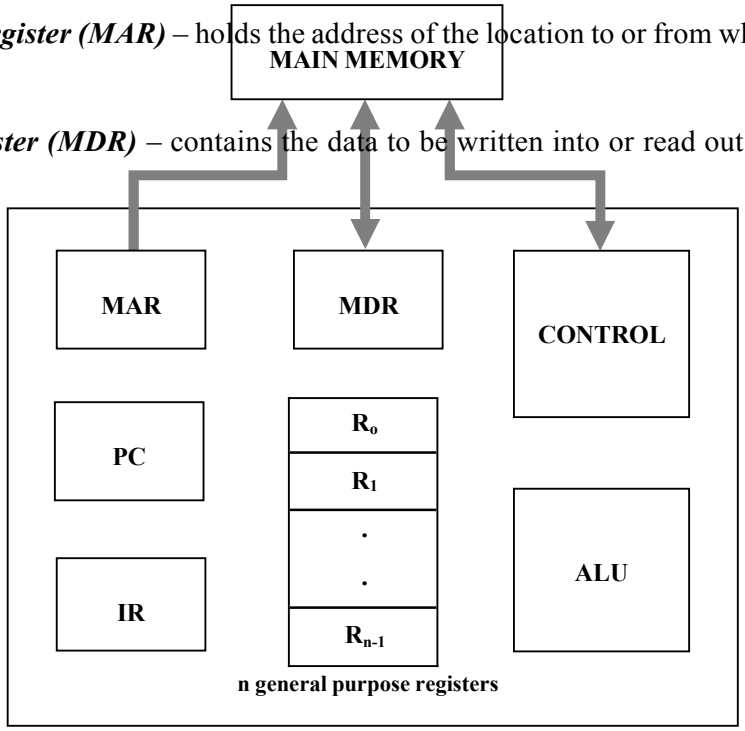


Figure 2- Processor

Steps involved during operation:-

1. Program is stored in the mainmemory
2. PC is set to point to the first instruction of theprogram
3. Contents of the PC are transferred to the MAR and a Read Control signal sent to the memory
4. After the access time, the addressed word (in this case the first instruction) is read out of the memory and is loaded into theMDR
5. Contents of the MDR are transferred to the IR. Now the instruction is ready to be decoded and executed.
6. If the instruction involves an operation to be performed by the ALU, the required operands are to be fetched from the memory (or CPU registers). This is done by sending its address to the MAR and initiating a Read cycle.
7. Operands are read from the memory into the MDR and are transferred from MDR to the ALU.
8. ALU will perform the desiredoperation.
9. If the result is to be stored in the memory, then it is sent to theMDR.

10. The address of the location where the result is to be stored is sent to the MAR and a Write cycle isinitiated.
11. At some point during the execution of the current instruction, the contents of the PC are incremented so that the PC now points to the next instruction to beexecuted.
12. As soon as the execution of the current instruction is completed, a new instruction fetch may bestarted.

1.5 COMPUTER MEMORY

A memory is just like a human brain. It is used to store data and instructions. Computer memory is the storage space in computer where data is to be processed and instructions required for processing are stored. The memory is divided into large number of small parts called cells. Each location or cell has a unique address which varies from zero to memory size minus one. For example if computer has 64k words, then this memory unit has 64 * 1024=65536 memory locations. The address of these locations varies from 0 to 65535.

The memory of computer is two types. - Primary Memory and Secondary Memory.

Primary Memory is the volatile memory and the Secondary Memory is the non- volatile memory. The volatile memory is erasable and the non-volatile memory stores the content that cannot be erased. Basically, when we talk about the data storage devices it is generally assumed to be those of secondary memory.

Primary Memory:

Primary Memory is accessible directly by the processing unit. RAM is an example of primary memory. As soon as the computer is turned off, the contents of the primary memory would be lost. You can store and retrieve data much faster with primary memory compared to secondary memory. And Primary memory is also more expensive than secondary memory as the size of primary memory is lesser than that of secondary memory.

Computer memory stores two things: i). instructions to execute a programme, and ii). data. When the computer is performing any job, the data that have to be processed are stored in the primary memory. This data may come from an input device like keyboard or from a secondary storage device like a floppydisk.

The following terms related to memory of a computer or Primary memory:

1. ***Random Access Memory (RAM):***The primary storage is called as Random Access Memory (RAM) because it is possible to randomly select and use any location of the memory, directly store and retrieve data. It takes same time to reach any address of the memory as it takes for the first address. It is also called read / write memory. The storage of data and instructions inside the primary storage are temporary. They disappear from RAM as soon as the power to the computer is turned off. The memories, which lose their content on failure of power supply, are known as volatile memories. So, we can say that RAM is a volatilememory.

2. ***Read Only Memory (ROM):*** There is another memory in computer, which is called Read Only Memory (ROM). The storage of program and data in the ROM is permanent. The ROM stores some standard processing programmes supplied by the manufacturers to operate the personal computer. The ROM can only be read by the CPU but it cannot be changed. The basic input/ output programme is stored in the ROM that examines and initialises various equipment attached to the PC when the switch is made ON. The memories, which do not lose their content on failure of power supply, are known as non- volatile memories. ROM is non-volatilememory.

3. ***PROM:***There is another type of primary memory in computer, which is called Programmable Read Only Memory (PROM). You know that it is not possible to modify or erase programs stored in ROM, but it is possible for you to store your program in PROM chip. Once the programmes are written it cannot be changedandremainintactevenifpowerisswitchedoff.Thereforeprogrammes or instructions written in PROM or ROM cannot be erased or changed.

4. ***EPROM:***This stands for Erasable Programmable Read Only Memory, which overcome the problems faced by PROM and ROM. EPROM chip can be programmed time and again by erasing previously stored information in it. Information stored in EPROM can be erased by exposing the chip to ultraviolet light for some time and the chip can reprogrammed by using a special programming facility. When the EPROM is in use, information stored in it can only be read.

5. ***Cache Memory:*** The speed of CPU is extremely high compared to the access time of main memory. Therefore the performance of CPU decreases due to the slow speed of main memory. To decrease the mismatch in operating speed, a small memory chip is attached between CPU and Main Memory whose access time is very close to the processing speed of CPU. It is called CACHE memory. CACHE memories are accessed much faster than conventionalRAM.

To store programs or data currently being executed or temporary data frequently used by the CPU. So each memory makes main memory to be faster and larger than it really is. It is also very expensive to have bigger size of cache memory and its size is normally kept small.

6. ***Registers:***The CPU processes data and instructions with high speed; there is also movement of data between various units of computer. It is necessary to transfer the processed data with high speed. So the computer usesa numberof special memory units called registers. They are not part of the main memory but they store data or information temporarily and pass it on as directed by the control unit.

The secondary Memory:

Secondary Memory is used for permanent storage of data in the computer. Some of the secondary storage devices are - Hard Disk Drives – which are the most common type of storage devices that are used in almost all the computer systems. The other ones include the Floppy Disk Drives, the CD ROM and the DVD ROM, the Flash Memory, the USB data cardetc.

Floppy Discs:

- Floppy Disks, which are soft magnetic disks, (often also called *Floppies* or *Diskettes*) are portable. They can be removed from a disk drive.
- Disk drives for floppy disks are called *Floppy Drives*. Floppy Disks are slower to access than hard disks and would have less storage capacity, however, they are much cheaper when it comes to cost.
- Floppies come in three basic sizes: Floppy Disks, initially as 8-inch (200 mm) media and later in 5.25-inch (133 mm) and 3.5-inch (90 mm) sizes. They were everywhere in the form of data storage and exchange from the mid-1970s well into the first decade of the 21st century. They

are read and written by a floppy disk drive (FDD).

- Figure of floppies of 8-inch (200 mm), 5.25- inch (133 mm) and 3.5-inch (90 mm) sizes shownhere.

Figure 3- Floppy Disks

- Floppies use where small files such as word processing, small spreadsheets and databases need to be moved from one computer to another. Useful to backup small data files.

Fixed Hard Discs (HDD):

- A Hard Disk Discs (HDD) is a data storage device used for storage and retrieving such stored digital information using rapidly rotating disks (Platters) coated with magnetic material.
- An HDD retains its data even when powered off. Data is read in a random-access manner, meaning individual blocks of data can be stored or retrievedinanyorderratherthansequentially.
- HardDiskDrivescanbeusedforstoring operating systems software and working data. These are suitable for any application which requires very fast access to data for both reading and writing too.
- Hard disk drives may not be suitable for applications which need portability. Almost all computers used a fixedhard disc. Used for on-line and real time processes requiring direct access. Used in file servers for computer networks to store large amount of data. Figure of 2.5"*SATA Hard Drive* shown here.
- This HDD is used to store operating system softwares which can be installed in computer to run it, and the data. Their capacity has been enlarged by the year.

Figure 4- Hard Disc Drive

Portable Hard Discs:

- Portable Hard Discs are good fun because you can carry data all over the place and transfer information, programmes, pictures betweencomputers.Portable disks connected with lap tap.
- Portable Discs are used to store very large files which need transporting from one computer to another and price is not an issue.
- Hard drives have to be handled quite carefully and when being transported should be wrapped in something soft and put in a padded bag. These are more expensive than other forms of removable media.

Figure 5- Portable Hard Disc

Magnetic Tapes:

- Magnetic Tape has been used for data storage for over 50 years. When storing largeamountsofdata,tapecanbesubstantiallylessexpensive than disk or other data storage options.
- Tape storagehasalwaysbeenusedwithlargecomputersystems.Modern usage is primarily as a high capacity medium for backups andarchives.
- Magnetic tapes are used for applications which require extremely large storage capacity where speed of access is not an issue.
- It is commonly used for backups of file servers for computer networks, in a variety of batch processing applications such as reading of bank cheques, payroll processing and general stock control.
- Writing and retrieving data is slow. It uses serial access for reading andwriting.

Figure 6- Magnetic Tapes

Optical backing storage media such as CDs and DVDs:

- CDs are used for large files (but smaller than 1GB) which are too big for a floppy disc to hold such as music and general animation.
- DVDs are used to hold very large files (several GB) such as movies. Both CDs and DVDs are portable i.e. they can be transported from one computer to another. Both can be used to store computerdata.
- CD ROM/DVD ROM Applications which require the prevention of deletion of data, accidental or otherwise. CDs used by software companies for distributing software programs and data; by Music companies for distributing music albums and by book publishers for distributing encyclopedias, reference books etc. DVDs used by filmdistributors.
- CD R/DVD R Applications which require a single 'burning' of data, e.g. CDs - recording of music downloads from the Internet, recording of music from MP3 format, recording of data for archiving or backup purposes. DVDs – recording of film movies and televisionprograms.
- CD RW/DVD RW Applications which require the updating of information and ability to record over old data. Not suitable for music recording but is very useful for keeping generations of files. DVDs have between five and ten times the capacity of CDs
- These are the smallest form of memory available in the market today.
- Widely used as removable storage.
- Though expensive than other forms they can be easily written to and updated.
- They are more robust than other forms of storage.

Figure 7- CD, DVD

Memory Sticks/Pen Drives:

USB flash drives are typically removable and rewritable, much smaller than a floppydisk.Storagecapacitiestypicallyrangefrom64MBto64 GB. USB flash drives offer potential advantages over other portable storage devices, particularly the floppy disk. They have a more compact shape, operate faster, hold much more data, have a more durable design and operate more reliably due to their lack of moving parts. Flash drives are widely used to transport files and backup data from computer to computer.

Figure 8- Pen Drive

Flash Memory Cards:

A Memory Card or Flash Memory Card is a solid-state electronic flash memory data storage device used with digital cameras, handheld and Mobile computers, telephones, music players, video game consolesandother electronics.

Figure 9- Memory Card

These days, most of the new PCs have built-in slots for a variety of memory cards; Memory Stick, Compact Flash, SD etc. Some digital gadgets support more than one memory card to ensurecompatibility.

The following table list out some of the key differences between the primary and secondary memory:

Primary memory	Secondary memory
Primary memory is known as main memory.	Secondary memory is known as additional memory or back memory.
These memories are also called as internal memory.	These memories are also called as external memory.
Primary memory is temporary	The secondary memory is permanent
Commonly used primary memory (main memory) available in the range of 512 MB to 8 GB RAMs.	Generally secondary memories range between 80 GB to 4 TB Hard Disc Drives.
The primary memory devices are connected to the computer through “slots”.	The secondary memory devices are connected to the computer through Cables.
The memory devices used for primary memory are semiconductor memories.	The secondary memory devices are magnetic and optical memories.

The primary memory is categorised as volatile and non volatile memories, RAM is the volatile memory and ROMis the non volatile memory.	The secondary memory is always non volatile.
The primary memory is composed of programs and data that are presently being used by the micro processor.	The secondary memory is enough capable to store huge amount of information.

1.6 PORTS AND CONNECTORS

What is a Port?

A portis a physical docking point using which an external device can be connected to the computer.It can also be programmatic docking point through which information flows from a program to computer or over the internet.

Characteristics

A port has the following characteristics:

- External devices are connected to a computer using cables and ports.
- Ports are slots on the motherboard into which a cable of external device is plugged in.
- Examples of external devices attached via ports are mouse, keyboard, monitor, microphone, speakers etc.

Following are few important types of ports:

Serial Port

- Used for external modemsand older computer mouse Two versions : 9 pin, 25 pin model.
- Data travels at 115 kilobits per second

Parallel Port

- Used for scanners and printers Also called printer port
- 25 pin model
- Also known as IEEE 1284-compliant Centronics port

PS/2 Port

- Used for old computer keyboard and mouse Also called mouse port.
- MostoftheoldcomputersprovidetwoPS/2port,eachformouseandkeyboard
- AlsoknownasIEEE1284-compliantCentronicsport

Universal Serial Bus *orUSB* Port

- ItcanconnectallkindsofexternalUSBdevicessuchasexternalharddisk,printer ,scanner, mouse, keyboardetc.
- It was introduced in 1997.
- MostofthecomputersprovidetwoUSBportsasminimum. Datatravelsat12megabitsperseconds
- USB compliant devices can get power from a USB port

VGA Port

- Connects monitor to a computer's video card.
- Has 15 holes.
- Similar to serial port connector but serial port connector has pins, it has holes.

Power Connector

- Three-pronged plug
- Connects to the computer's power cable that plugs into a power bar or wall socket

Firewire Port

- Transfers large amount of data at very fast speed.
- Connects camcorders and video equipments to the
- computer Data travels at 400 to 800 megabits per seconds
- Invented by Apple
- Threevariants:4-PinFireWire400connector,6-PinFireWire400connectorand9-Pin FireWire 800connector

Modem Port

- Connects a PC's modem to the telephone network

Ethernet Port

- Connects to a network and high speed Internet. Connect network cable to computer.
- This port resides on an Ethernet Card.
- Data travels at 10 megabits to 1000 megabits per seconds depending upon the network bandwidth

Game Port

- Connects a joystick to a PC
- Now replaced by USB

Digital Video Interface(DVI) port

- Connects Flat panel LCD monitor to the computer's high end video graphic cards.
- Very popular among video card manufacturers.

Sockets

- Connect microphone, speakers to sound card of the computer

1.7 Input Devices

An input device is a piece of hardware that is used to enter data into a computer.There are many different kinds of input devices. They are divided into two categories

(1) Manual input devices (devices that need human involvement to inputdata)

(2) Automatic input devices (devices that do not need human involvement to inputdata)

Manual Input Devicesare:

(i) Keyboard

(ii) PointingDevices

(iii) Scanner

(iv) DigitalCamera

(v) Microphone

(vi) MusicalKeyboard

(vii) RemoteControl

In the first section, we will discuss manual input devices while in the next section we will discuss automatic input devices or automatic data capture devices.

Keyboard

The keyboard is the most common and widely used input device.

Figure 10 - Keyboard

It is made up of buttons called 'keys'. The keys are arranged into sections:

- Alphabetkeys
- Function or F keys (F1, F2,F3)
- Numeric keys (one set above the alphabet keys and a numeric keypad on theright)
- Arrowkeys
- Command keys (insert, delete, home, end, pageup/down)

- Most keyboards are called 'QWERTY' keyboards. This name comes from the first six letters on the top row of the alphabet keys.
- Using a keyboard for too long can lead to health problems such as repetitive strain injury (RSI).
- To try to overcome this, different styles of keyboard have been developed, for example, the ergonomic keyboard. They are supposed to put your hands into a much more natural position than a traditional keyboard.

Pointing Devices

Pointing devices are input devices that are used to control a pointer (cursor) on a screen. Pointing devices are frequently used with Graphical User Interface (GUI) to input commands by selecting icons.

Following are some important pointing devices:

- Mouse
- Touchpad
- Trackball
- Joystick
- Touchscreen
- GraphicTablet
- Lightpen

Mouse

- Mouse is a pointing device that controls the movement of the cursor or pointer on the display screen (monitor or LCD) of computer system.
- A mechanical mouse usually has two buttons, a right and left one and a rubber ball under it to detect the movement.
- An optical mouse has two buttons and it uses light-emitting diode (LED) and optical sensor in place of rubber ball to detect the movement.

Figure 10 - Mouse

Touchpad

- Touchpad is a pointing device found on most laptops and used instead of a mouse since it takes up less space.
- The user moves a finger across the touch pad and this movement data is sent to the laptop.
- Usually used to control the pointer in a GUI.

Figure 11 - Touchpad

Trackball

- This pointing device is not moved about like a mouse, instead it has a large ball that the user spins.
- Data about which direction the ball is spun is passed to the computer.
- Tracker balls are often used by people with **limited movement** (disabled).

Figure 12 - Touchpad

Joysticks

- Used to be popular with gamers but have slowly been replaced by other types

of game controller.

- Joysticks can also be used for controlling machines such as cranes, trucks and powered wheelchairs.

Figure 13 - Joysticks

Touch screen

- A touch screen is the only device which works as both an input and an output device. You view the optionsavailabletoyouonthescreen(output)andyouthenuseyourfingertotouchtheoptionthat you have chosen(input).
- Touchscreensareeasytouseandareoftenfoundinpublicplacessuchascashpointsat banks,ticket collection terminals at theatres or airports, information centers atmuseums.

Graphics Tablet

- **A graphics tablet consists of a flat pad (the tablet) on which the user draws with a special pen.**
- **As the user draws on the pad the image is created on the screen.** Using a graphics tablet a designer can produce very accurate on-screen drawings as if they were drawn on paper.
- Graphics tablets are often used by graphics designers and illustrators.

Light Pen

- **A light pen is a device used as a pointing device or to 'write' on the screen of a computer.** It is connected with computer system through a cord which makes it awkward to be used.
- Light pens are **rarely used** today since graphics tablets and high-quality touch screens provide similar functionality.

Figure 14 - Light pen

Scanners

- Scanners can be used to convert images or text on paper into a digital format that can be

used by the computer.

- Ascannerworksbyshiningabeamoflightontothesurfaceoftheobjectthatyouarescanning.
- Thislightisthenreflectedbackontoasensorthatdetectsthecolourofthelight.Thisisthenusedtobuild up the digitalimage.

Digital Camera

- A device that captures digital photographs.
- Most digital cameras do not directly input data into a computer - they store photographs on memory cards.
- The photographs can later be transferred to a computer.

Digital camera

- A modern digital camera can capture 10 Megapixels or more per photograph - that's 10,000,000 coloured dots (pixels) in every photo.

Figure 15 -Digital camera

Webcam

A webcam is short for 'web camera'. A webcam is an input device because it captures a video image of the scene in front of it. It is either built in to the computer (e.g. laptop) or it is connected through an USB cable. It is used in video chatting (video calling) over the Internet and sometimes used for security purposes as well.

Figure 16 -Webcam

Microphone

A microphone can be used to input sound. The sound is detected by the microphone and an electrical signal is transmitted to the computer. Special hardware is used to convert this analogue data into digital data so it can be stored and manipulated.

Remote Control

A remote control is a hand-held device which is used to control a machine from a short distance away. Remote controls need line-of-sight in order to send their signals to the

receiving device, obstacles such as furniture or walls can block the signal.

Examples of use for remote controls:

- Televisions
- Musicsystems
- Lightingsystems
- Heatingsystems

Figure 17 -Remote control

Automatic Data Capture Devices

By using these devices, data is captured without the human involvement. Important Automatic Data Capture Devices & Methods are listed below:

1. OCR and OMRreaders
2. MICRReader
3. BarcodeReader
4. RFID tagreader
5. Magnetic stripreader
6. Smart cardreader
7. Biometric data capturedevices

OCR and OMRReaders

Optical Character Recognition (OCR) is a software which extracts the text from the image of scanned document. OCR software compares the shape of each possible text character in the image data with sample(template)foreachcharacterstoredincomputer.Whenitrecognizesacharacterthenaddsitin the output datasequence.

Optical Mark Reading (OMR) software is used to detect the presence of marks (shaded regions) in certain positions on a paper form. Unlike OCR, it cannot detect the characters. OCR software is used to extract marked answers in multiple-choice questions, survey

results, votes in elections etc.

MICR (Magnetic Ink Character Recognition)

MICR software scans documents for numerals and symbols printed in magnetic ink. The use of magnetic ink makes documents harder to copy. MICR is mostly used by bank cheque-processing systems for input of printed items on the bottom of each cheque.

Magnetic Stripe Reader

Magnetic stripe readers are used to read the magnetic strips usually printed on the back of debit cards, credit cards, library cards etc. The magnetic stripe has 3 independent parts that can store different types of information. It can only store a small amount of data but this is sufficient for many purposes.

Smart Card Reader

A smart card is a plastic card with a built-in microprocessor, used typically to perform financial transactions. It resembles a credit card in size and shape. While making a payment, a smart card is inserted in the smart card reader. The user enters a four digit Personal Identification Number (PIN) to access the data stored in card. The smart reader communicates with the built-in processor of card to match the PIN with already stored PIN and also authenticates that card is

Barcode Reader

A barcode is a set of parallel lines in contrasting colours usually black lines on a white background. Barcodes are used to identify items of merchandise, resources, membership cards or documents. A barcode may represent numeric digits or alphanumeric characters.
A barcode only tells about the manufacturer and product only. A barcode reader is usually used at Point-of-Sale (POS).

RFID Tag Reader

A Radio Frequency Identification (RFID) tag reader reads an ID code from a small tag using short range wireless signals.

TheIDcodeisstoredinRFIDtag.AnRFIDtagconsistsofReadOnlyMemory(ROM)tostorecod
e,a small processor and an antenna to transmit and receive signals. The size of RFID tag
is very samll in millimetersusually.

1. Used with hotel roomkeys
2. Used with pets and farmlivestock

1.8 OUTPUTDEVICES

Following are few of the important output devices which are used in a computer.

Monitors GraphicPlotter Printer

Monitors

Monitors,commonlycalledasVisualDisplayUnit*VDU*,arethemainoutputdeviceofacomputer.It formsimagesfromtinydots,calledpixelsthatarearrangedinarectangularform.Thesharpness oftheimagedependsuponthenumberofpixels.

There are two kinds of viewing screen used for monitors.

1. Cathode-Ray Tube *CRT*
2. Flat- Panel Display

Cathode-Ray Tube *CRT* Monitor

- The CRT display is made up of small picture elements called pixels. The smaller the pixels, the better the image clarity, or resolution. It takes more than one illuminated pixel to form whole character, such as the letter ‘e’ in the word help.
- A finite number of characters can be displayed on a screen at once. The screen can be divided into a series of character boxes - fixed location on the screen where a standard character can be placed. Most screens are capable of displaying 80 characters of data horizontally and 25 lines vertically. There are some disadvantages of CRT:

  1. Large in Size
  2. High power consumption

Figure 18 -CRT Monitor

Flat-Panel Display Monitor

- The flat-panel display refers to a class of video devices that have reduced volume, weight and powerrequirementincomparisontotheCRT.Youcanhangthemonwallsorwearthemony our wrists. Current uses of flat-panel displays include calculators, video games, monitors, laptop computer, graphicsdisplay.

- Flat panel is divided into two categories

    1. **Emissive Displays -** The emissive displays are devices that convert electrical energy into light. Example are plasma panel and LED*Light − EmittingDiodes*.

    2. **Non-Emissive Displays -** The Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Example is LCD*Liquid −CrystalDevice*

Figure 19 -LCD Monitor

Printers

Printerisanoutputdevice,whichisusedtoprintinformationonpaper.

Therearetwotypesofprinters:

- Impact Printers
- Non-Impact Printers

Impact Printers

Theimpactprintersprintthecharactersbystrikingthemontheribbonwhichisthenpressedon thepaper.

Characteristics of Impact Printers are the following:

- Very lowconsumable costs
- Very noisy
- Useful for bulk printing due to low cost
- There is physical contact with the paper to produce an image These printers are of two types
    - Character printers
    - Line printers

Character Printers

Character printers are the printers which print one character at a time. These are further divided into two types:

1. Dot matrix printer
2. Daisy Wheel

Dot Matrix Printer

In the market one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price. Each character printed is in form of patternofdotsandheadconsistsofaMatrixofPinsofsize5 7,7 9,9 7*or*9 9whichcomeout to formacharacterthatiswhyitiscalledDotMatrixPrinter.

Advantages

- Inexpensive Widely Used
- Other language characters can be printed

Disadvantages

Slow Speed PoorQuality

DaisyWheel

Headislyingonawheelandpinscorrespondingtocharactersarelikepetalsof Daisy*flower name* thatiswhyitiscalledDaisyWheelPrinter.Theseprintersaregenerallyusedforword-processing inofficeswhichrequireafewletterstobesenthereandtherewithverynicequality.

Advantages

- More reliable than DMP Better quality
- The fonts of character can be easily changed

Disadvantages

- Slower than DMP Noisy
- More expensive than DM

Figure 20 -DaisyWheel

Line Printers

Line printers are the printers which print one line at a time.

Figure 21 - Line Printer

Theseareoffurthertwotypes

- DrumPrinter
- ChainPrinter

Drum Printer

This printer is like a drum in shape so it is called drum printer. The surface of drum is divided into number of tracks. Total tracks are equal to size of paper i.e. for a paper width of 132 characters, drum will have 132 tracks. A character set is embossed on track. The different character sets available in the market are 48 character set, 64 and 96 characters set. One rotation of drum prints one line. Drum printers are fast in speed and can print 300 to 2000 lines per minute.

Advantages

- Very high speed

Disadvantages

- Very expensive
- Characters fonts cannot be changed

Chain Printer

Inthisprinter,chainofcharactersetsareusedsoitiscalledChainPrinter.Astandardcharacter setmayhave48,64,or96characters.

Advantages

- Character fonts can easily be changed.
- Different languages can be used with the same printer.

Disadvantages

- Noisy

Non-impact Printers

Non-impact printers print the characters without using ribbon. These printers print a complete page at a time so they are also called as Page Printers.

Theseprintersareoftwotypes LaserPrinters and InkjetPrinters

Characteristics of Non-impact Printers

- Faster than impact printers.
- They are not noisy.
- High quality.
- Support many fonts and different character size.

Laser Printers

Thesearenon-impactpageprinters.Theyuselaserlightstoproducethedotsneededtoformthe characterstobeprintedonapage.

Advantages

- Very high speed
- Very high quality output
- Give good graphics quality
- Support many fonts and different character size

Disadvantages

- Expensive.
- Cannot be used to produce multiple copies of a document in a single printing.

Figure 22 - Drum Printer

Inkjet Printers

Inkjet printers are non-impact character printers based on a relatively new technology. They print characters by spraying small drops of ink onto paper. Inkjet printers produce high quality output with presentable features.

Theymakelessnoisebecausenohammeringisdoneandthesehavemanystylesofprinting modesavailable.ColourprintingisalsopossibleSomemodelsofInkjetprinterscanproduce multiplecopiesofprintingalso.

Advantages

- High quality printing
- More reliable

Disadvantages

- Expensive as cost per page ishigh
- Slow as compared to laserprinter

Figure 22 - InkJet Printer

OVERVIEW OF C

Executing a C program:

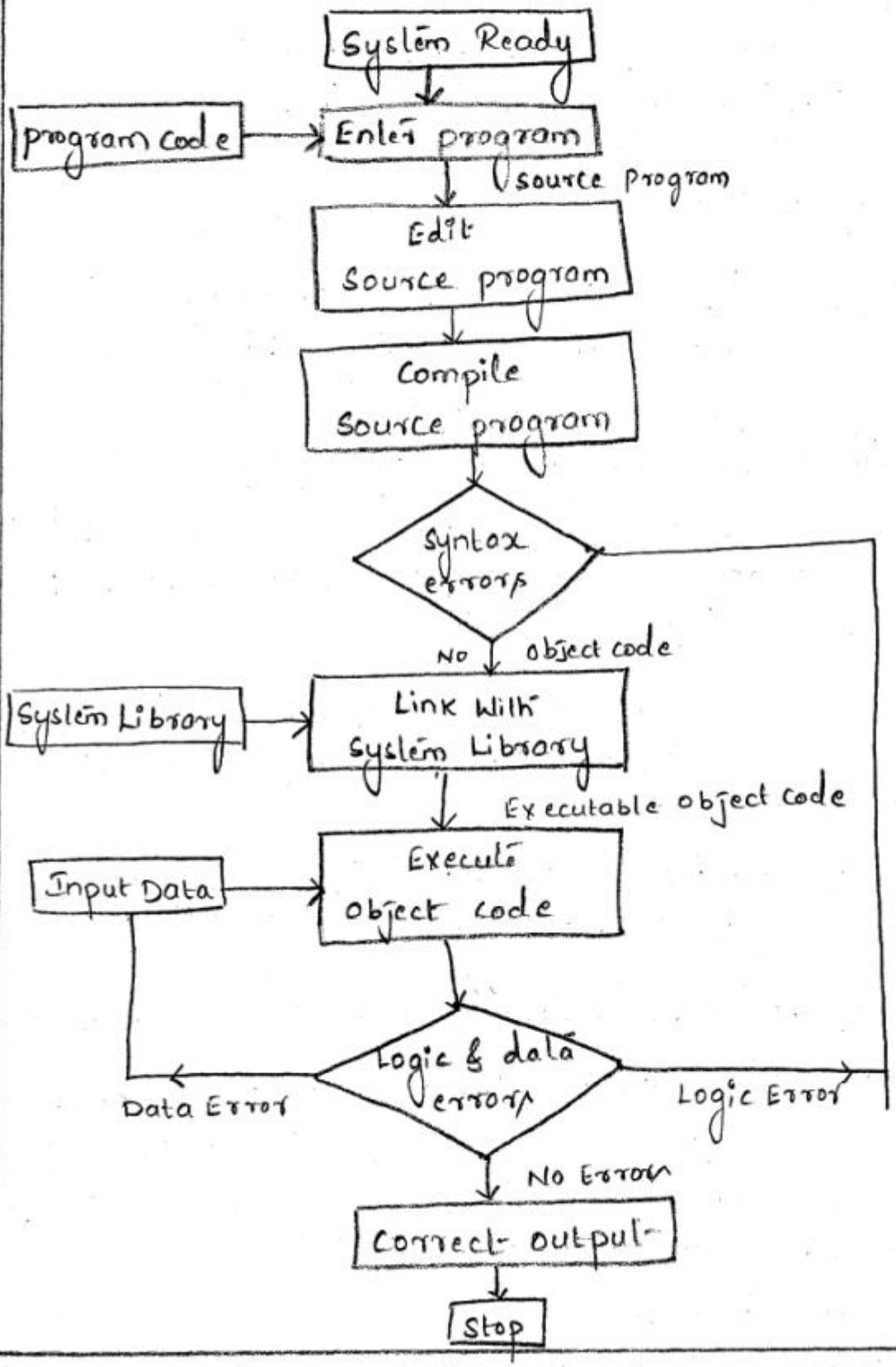


Fig: process of Compiling & running a C program

Executing a program written in C involves a series of steps They are

1. Creating a program
2. Compiling the program
3. Linking the program with functions
4. Executing the program.

1. Creating a program

* First step is creating & editing the program
* C program is written using Text Editor, such as Borlond C/C++ 3.0, Notpad etc
* Save the program by using (.C) Extension
* File saved with (.c) extension is called "Source program"
* The command for creating a file is `vi or gedit filename.c`

2. Compiling the program

* C source code with (.c) extension is given as input to compiler & compiler convert it into Equivalent Machine Instruction.
* Compiler checks for errors. If source code is error-free then code is converted into object file (.obj)
* The compilation command under UNIX is `cc filename.c`
* During compilation if compiler finds any error then it will report it. User have to re-edit the program
* After re-editing compiler again check for any error. If Program is error-free, program is linked with appropriate libraries

3. Linking the programs with functions

* program is linked with included header files & with other libraries
* This process is executed by Linker

4. Executing the program

* Execution is a simple task. The command `a.out` would load the executable object code into memory & execute the instructions.
* During Execution, the program may request for some data to be entered through the Keyboard.
* Sometimes program does not produce desired results, programmer has to check for program logic or data.

Structured and Modular Programming

Structured programming

* Initiated by Edsger Dijkstra to solve programming problems
* programs are written using only 3 control structures i.e sequencing, selection & repitation
* Each structure is entered at the top & excited at bottom

Modular programming

* It is a technique which allows a program to be decomposed into number of individual modules or subprograms, which can be developed easily & independently

Advantages

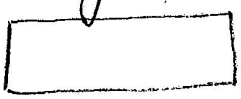
1. programs have better logical clarity
2. Easy to develop, debug & maintain
3. Module can be accessed several times & each time different information can be processed, which avoids repitation of code
4. permits Information Hiding, i.e rest of the program need not know how the information is processed by particular module.

FLowcharts

- Flowchart is a diagram showing a sequence of activities to be performed for the solution of a problem
- Activities in the flowchart are connected by flow Lines indicating sequence of Operations

1. Data Symbol (Input/output)

- used to indicate data input or output Operations
- Commands like INPUT, READ, WRITE & PRINT are written in it along with the parameters

2. Process Symbol 

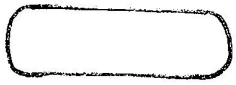
- used for data manipulation, assignment of Values to Variables
  - → (←) Backword arrow used to assign the value of expression to Variable.

3. predefined process symbol: 

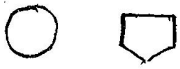
- It is also called as subprogram symbol.
- used for predefined subprogram [function or subroutine]
- Separate flowchart is drawn for a subprogram.

4. Decision Symbol: 

- It is used where decision is to be taken to select one of two or more alternative paths
- Condition is written in this symbol.

5. Terminator Symbol: 

- used to denote the beginning & end of flowchart
- Words like START & END are written in it

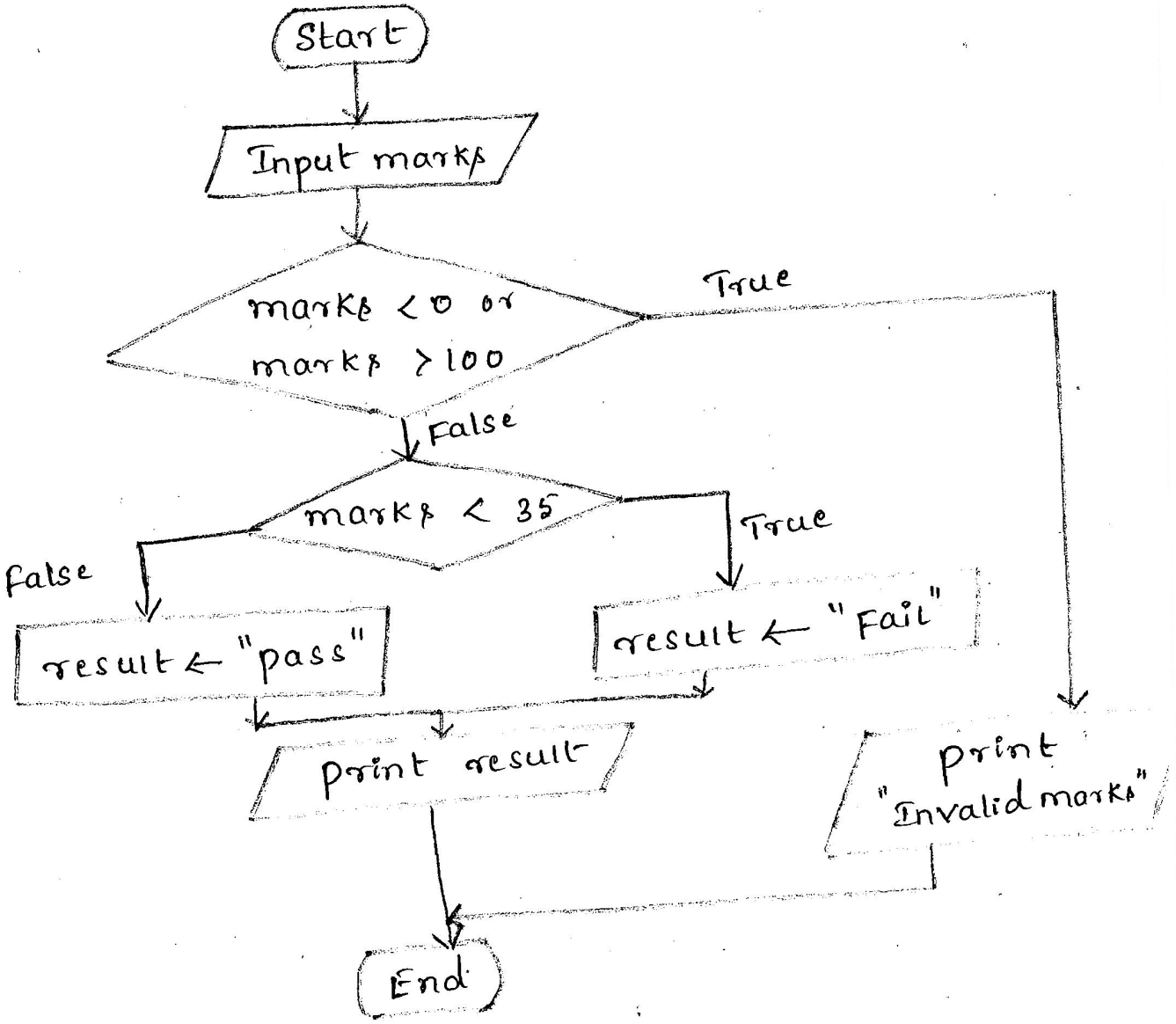
6. Connector Symbol: 

- It is used to show the connection between two or more ~~paths~~ parts of flowcharts drawn at different places or on different pages
- These symbols are useful when drawing lengthy flowcharts
- Letter or number is written inside the symbol

7. Flow Lines: → ↓

- used to connect flowchart symbols, indicating the sequence of activities to be performed

Example: Flowchart to determine exam results in a single subject with data validity check



Algorithms and pseudocode.

Algorithm:

- It is an effective step-by-step procedure to perform calculations
- It is expressed as a finite list of well-defined instructions
- When executed, these instructions produce desired output from the given input & terminate.

- Algorithms are expressed in different notation. Common notations are natural Languages, pseudocode & flowcharts & programming Languages like C & C++
- Algorithms written in natural Language are easy to understand but there are ambiguity. To avoid this pseudocode & flowcharts are used.
- Objective of an is to develop an algorithm that is elegant, compact, fast & less memory hungry.
- To write efficient algorithms, it is essential to use suitable data structures to represent data to be processed.

Pseudocode:

pseudocode

- It is an informal & environment-independent high level description of a computer program (or) an algorithm intended for human reading

→ pseudocode uses the structural conventions of a programming Language but avoids unnecessary details such as Variable declaration, Language specific instructions punctuations etc

→ pseudocode is similar to computer program mixed with natural Language descriptions & mathematical notations.

→ pseudocode is flexible in that, it need not follow strict Syntax rules.

Example: pseudocode to calculate the Volume & Surface area of a sphere

```
program Sphere
    read radius      // read the radius of sphere from keyboard
    PI = 3.141593
    Volume = (4/3) PI radius ^ 3
    Surf_area = 4PI radius^2
    print Volume, Surf_area
end
```

Note: ^ → exponentiation Operator
// → Comment Line

Example: pseudocode to read the marks of student & determines whether student has passed or not

```
program ExamResult
    read marks
    if marks >= 40
            result ← "pass"
    else    result ← "fail"
    print result
end
```

Introduction to C programming Language

- C Language was described by Brian Kernighan & Dennis Ritche & is popularly known as K&R C
- As the popularity of C began to increase significantly, developers provided non-compatible extensions to Language Hence American National standard Institute (ANSI)

Standardized C Language in 1989 by introducing new features to obtain Superset of K & R C. This Version is referred as ANSI C, Standard C or C89

- International Organization for Standardization (ISO) adopted ANSI C as a standard in 1990. This standard is referred as C90
- In 1999, a new standard for the C Language was published Jointly by ISO & IEC [International Electrotechn.-cal Commission]. This standard is referred as C99
- Since ANSI C is widely available on almost every platform, In 2007 work began for the next standard of C language, informally called C1X

C programs

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Structure of C program

```
Documentation Section
Link Section
Definition Section
Global Variables Declaration
int main()
{
    Local Variable declaration
    Executable statements
    return 0;
}
```

Subprogram Section

Function 1

Function 2

-

-

Function n

(user defined functions)

Documentation Section:

- It consists of set of comment lines giving the name of the program, the author & other details, which the programmer would like to use later

Eg: /* program to find area of circle */

Link Section:

- C compilers are provided with standard Library, which consists of definitions of built-in functions
- Since these functions are readily available. we need not to write them, they are simply utilized by our program.
- In Order to use them, we need to include some files as part of our program. These files are called header files Since they are included in the beginning of the program

Eg of examples of header files are stdio.h, conio.h, math.h etc

- preprocessor directive #include is used to include these files.

Eg: #include<stdio.h> → Contains declarations of function required for Input/output Operation

#include<conio.h> → Contains declaration of functions required for console I/O Operations

Definition Section :

- This section assign Symbolic names to constants & define macros
- The preprocessor directive #define is used for this purpos

Eg: #define PI 3.14 ⇒ This assigns the symbolic name PI to the constant value 3.14

Global Variables :

- Global Variables are those, which are required to accessed by all the functions defined after their declaration
- So, the variables declared before the main() can be accessed by all the functions which allow their declarations.

main() :

→ Every C program will have one main() . This is where the execution of a program starts.

→ '{' opening brace marks beginning of program & '}' closing brace marks end of the program

→ The statements enclosed within the Opening brace & Closing brace form the body of the main()

→ It consists of 2 parts

1. Local Variables Declaration : where all the Variables, which are accessed only by main() are declared

2. Statements, which include executable statements

-> After closing brace of main(), user-defined functions, if any, are defined

Example: program to calculate Simple Interest

```
#include<stdio.h>
int main(void)
{
    int period;          /* read input period */
    float rate, principal, si;
    printf("enter principal, rate and period\n");
    scanf("%f %f %d", &principal, &rate, &period);
    si = (principal * period * rate) /100;
    printf("Simple Interest = %f", si);
    return 0;
}
```

Note: 1. In C, almost all the statements ends with semicolon (;)

2. Comments line are non-executable part of C program, they are useful for program reader.
   - They gives additional information to the reader which is delimited with /* and */

Example: /* program to illustrate use of comments */
program accepts 2 integers & prints their sum */

```
#include<stdio.h>
int main()
{
    int a, b;        /* input numbers */
    int sum;         /* Sum of a & b */
    scanf("%d %d", &a, &b); /* read numbers a & b */
    Sum = a+b;       /* determine the Sum */
    printf("Sum = %d", sum); /* print Sum */
    return 0;
}
```

Tokens

- In C programming punctuation, individual words, characters etc are called tokens
- Tokens are the basic building blocks of C programming
- They are the smallest individual units. C has six types of token,

NO	Token Type	Example
1.	Keyword	float, while
2.	Constants	-15.5 , 100
3.	Strings	"ABC", "year"
4.	Operators	+, -, ++, /

5. Identifiers — main, amount

6. Special Symbols — [], {}, @

CHAPTER 2:

Representing Data:

- Features of C Language used to represent data in program
Character
- These include character set, keywords, basic data types constants, identifiers, Variables & Symbolic constants

1. Character Set

- It is a set of characters used in C programs.
- It includes uppercase Letters [A---Z], Lowercase Letters (a---z), digits (0---9), space, Special Symbols Control characters & extended characters

Uppercase Letters	A---Z
Lowercase Letters	a---z
Decimal Digits	0---9
Space	
Special symbols	Operator symbols (+ - * / % <> = &| ~ ? : ,), brackets (() [] {}), Separators (, : ;), delimiters (" ') & other Symbols (#
Control characters	alert (\a), backspace (\b), Carriage return (\r), newline (\n) horizontal tab (\t), Vertical tab (\v), formfeed (\f)
NULL character	\0
Extended character	Locale-Specific with implementation dependent values

-> Special Symbols include

* Operator Symbols [+ - * / % < > = & | ! ^ ~ ? : ,]
* bracket Symbols [() [] {}]
* Separators [. , ;]
* Other Symbols [# _ \ ]

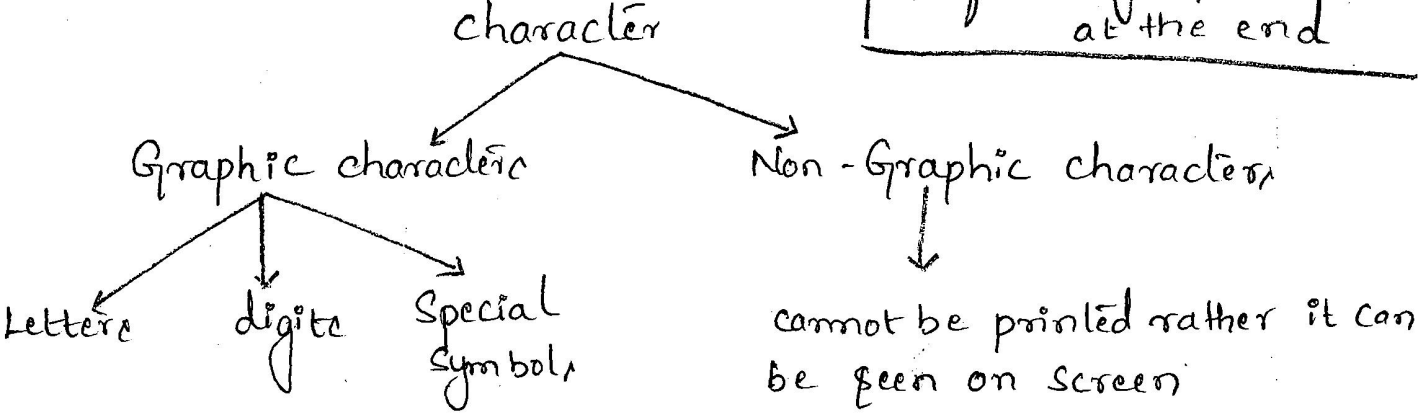
Special characters in the character set of the C Language

Character Name	Symbol	Description
plus	+	Addition & unary plus
Minus	-	Subtraction or negation
Asterisk	*	Multiplication & pointer dereference operators
Forward slash	/	Division
percent	%	Modulo arithematic (remainder after integer division)
Less than	<	Less than Operator
Greater than	>	Greater than Operator
EQual	=	used in assignment Operators
Ampersand	&	Bitwise and Logical AND, address-of operator
pipe	|	Bitwise and Logical OR
Exclamation	!	Logical NOT
Carat	^	Logical exclusive OR
Tilde	~	Bit-wise complement
Question mark	?	used in conditional Operator (?:)
colon	:	used in conditional Operator (?:)
comma	,	Comma Operator also used as Separa- tor

Left and right parenthesis	()	Used in expressions and function calls
Left and right square brackets	[]	Used in array subscripts
Left and right curly braces	{}	Used in block of code and initialization list
period	.	Structure member
Semicolon	;	Statement terminator
Double Quote	"	String delimitors
single Quote	'	character delimiters
Hash	#	Other Symbols
underscore	_	Used in identifier names
Backslash	\	Used to form escape sequences

→ Depending on whether a character can be printed or not it is characterized into 2 types

Refer Trigraph sequences at the end



→ Control characters are included in character constant and string literals using escape sequences

→ Escape sequence consists of a backslash (\) followed by one or more graphic character

Control character	Symbol	Description
\n	→ newline character	→ cursor moves to the initial or leftmost position on next line
\t	→ tab character	→ causes the cursor to move to next tab position
\a	→ alert character	→ causes the computer to produce an audible or visual alert

Note: blanks [spaces], newlines horizontal & Vertical tabs & form feeds are collectively called whitespace.

\0 → null character → used as string terminator.

Keywords :-

→ Keyword is a reserved word having predefined meaning that cannot be changed.

→ ANSI C [C89] defines 32 keywords. Keywords are grouped into 2 broad categories

* Data types
* Control flow

Category		Keywords
Data Types	Basic data types	char int float double
	Type modifiers	short long signed unsigned
	storage classes	auto static register extern
	user-defined data types	enum struct union typedef
	Type Qualifiers	const Volatile
	Other	Void sizeof
Control flow	Selection	if else switch case default
	Loops	for while do
	Transfer of control	break continue return goto

ANSI C Keywords.

Basic Data Types :-

Data types are keywords which define the type of data stored on it

→ During the execution of a program, the computer processes different types of data elements such as number, characters and text

→ Type of data element is specified using type specifiers which include basic data types, type modifiers and type Qualifiers.

→ C Language provides 4 basic data types

* int
* char
* float
* double

Refer Appendix 1 at the end

→ Every data element require some memory [RAM] for its storage, which depends upon various factors such as type of

of data, the range of possible values & the precision [number of significant digits in a floating point value]

Data Type	Meaning	Size (bytes)	Range	precision
char	character in C character set	1	-128 ---- 127	
int	an integer number	2	-32768 ----- 32767	
		4	-2147483648 --- 2147483648	
float	Single precision [less accurate floating-point number	4	3.4×10^{-38} ---- 3.4×10^{38}	6
double	Double precision (more precision) accurate) floating-point number	8	1.7×10^{-308} ---- 1.7×10^{308}	15

Characteristics of basic data types in C Language.

Note: on 16-bit platforms such as DOS e.g. Turbo C/C++
on 32-bit platforms such as Windows, Linux etc.

Constants :- [Literal or Literal Constant]

→ Constant is an entity whose value cannot be changed during program execution

→ C supports four types of constants

- * Integer Constants } Numeric constants
- * Floating Constants
- * character Constants < single character Const / string "
- * Enumeration Constants

Type of Constant	Description	Examples
Integer constant	Number having Integer Value	10, 1234
Floating Constant	number having real value	0·15, 2·0
Character Constant	Single character or more characters enclosed within Single Quotes	'A', '+', '0'
Enumeration Constant	user-defined constants of type int	Jan, Feb, Red

Types of constants in C Language

Integer Constants:-

→ Integer Constant is a number that has an integer Value

→ Integer Constants Specified in 3 forms: decimal, octal, hexadecimal

→ Decimal Integers consist of a set of digits, 0 through 9 preceded by an Optional - or + sign

Eg: 123, -321, 0, 654321, +78

→ Spaces, commas & non-digit characters are not permitted between digits

Eg: 15 7500, 20,500 $1000 are illegal nos

→ Octal Integer Constant Consists of any combination of digits from the set 0 through 7, with a leading 0

Eg: 037 0 0435 0551

→ Hexadecimal Integer constant Consists of sequence of digits preceeded by 0x or 0X. Letter 'A' through F represent the numbers 10 through 15.

Eg: 0X2 0x9F 0Xbed

Note: Larger Integer constants are stored on 16-bit | 32-bit machines by appending Qualifiers such as U, L & UL to the Constants

56789U or 56789u (unsigned integer)

98761234 7U or 98761234 7u (unsigned long integer)

9876543L or 9876543l (Long Integer)

Program: Representation of integer constants on a 16-bit computer

```
#include <stdio.h>
#include <conio.h>
Void main()
{
    printf("Integer Values \n\n");
    printf("%d %d %d", 32767, 32767+1,
                                32767+10);
    printf("\n");
    printf("Long Integer Values \n\n");
    printf("%ld %ld %ld", 32767L, 32767+1L,
                                32767+10L);
}
```

Output: Integer Values

32767 -32768 -32759

Long Integer Values

32767 32768 32777

Floating Constants :-

→ Floating Constant has a significant part called mantissa followed by an exponent part & a type suffix

→ Significant part Contain a digit sequence representing a whole number part, followed by a period (.), followed by a digit sequence representing a fraction part

→ We can omit either the whole number part or the fraction part, but not both & period must be present if the exponent part is not specified.

→ Several floating constants containing only the significand part are

12.345 12. .345 12345678.123456

→ Exponent part includes the letter e or E, followed by an optional sign (+ or -) followed by digit sequence

→ Exponent indicates power of 10 by which significand is to be scaled. Several valid floating constants containing exponent part are

1.23e10 1.e5 .1e90 1e20 1e-20

Note: Floating Constant Cannot Contain any other character, Such as comma, space or Special Symbols. Several invalid floating-point constants are given below

21,345.50	±12.0	$12.5	75.2%	500
3-e10	e-20	1.23E1.5	1.1×10^5	-12.+34

Character Constants :-

→ character constants in C Language can be grouped into two broad categories

* Integer character
* Single character Constant
* Wide character
* String Constant

→ Single character constant [character Constant] contains a single character enclosed within a pair of single Quotes marks.

Eg: '5' 'x' ';' ' '

→ character constants have integer values known as ASCII values.

```
Eg: printf("%d", 'a');
```

The above statement would print the number 97

```
printf("%d", 'A');
```

The above statement would print the number 65

```
printf("%d", '97');
```

The above statement would output the letter a

→ String Constant is a sequence of characters enclosed in double Quotes. characters may be letters, numbers, Special characters & blank space

Eg: "Hello" "1987" "WELLDONE" "5+3"

Note: Character constant is not equivalent to the String constant.

→ C supports some Special backslash ~~Constan~~ Chara Constants that are used in output functions.

→ Note that each one of them represents one characti although they consist of two characters. These characte Combinations are known as escape characters

Backslash character Constants

Constant	Meaning
'\a'	audible alert (bell)
'\b'	backspace
'\f'	form feed
'\n'	new line
'\r'	carriage return
'\t'	horizontal tab
'\v'	Vertical tab
'\''	
'\"'	Single Quote

'\"'	double Quote
'\?'	Question mark
'\\'	backslash
'\0'	null

Identifiers :-

-> Identifiers are the names of Variables, functions and arrays. These are user defined names & consist of sequence of digits & letters, with a letter as a first character.

-> C is a Case Sensitive Language, both uppercase and Lowercase Letters are permitted

-> usually uppercase Letters are used for Symbolic Constants [PI] & lowercase Letters for all other identifiers

1. first character must be an alphabet (or underscore)
2. Must consist of only letters, digits or underscore
3. Only first 31 characters are significant
4. Cannot use a Keywords
5. Must not contain white space

Examples:	Valid Identifiers	InValid Identifiers
	B	π
	Sum	X.Y
	_X55	7wonders
	MAX_ITEMS	a&b
	float_num	marks(1)
	_X1_X2	long

Variables :-

- A Variable is a named memory Location, the value of which can change during the execution of the program containing it.
- Variable name should be a Valid C Identifier.
- Variable names may consist of letters, digits, & the underscore (_) character subject to following Conditions

1. They must begin with a letter. Some Systems permit underscore as the first character
2. It should not be a Keyword
3. White Space is not allowed
4. ANSI Standard recognizes a length of 31 characters. However, Length should not be normally more than eight characters. Since only the first 8 characters are treated as Significant by many Compilers.

Variable name	Valid?	Remark
First_tag	Valid	
price$char	Not Valid	char is a Keyword
group one	Not Valid	Blank Space is not permitted
price$	Not Valid	Dollar Sign is illegal
int_type	Valid	Keyword may be part of a name

- In C, all the Variables should be declared before they are used. Syntax-o'

Declaration of Variables :-

- After designing Suitable Variable names, we must declare them to the Compiler. Declaration does two things

1. It tells the compiler what the Variable name is
2. It Specifies what type of data the Variable will hold.

- Syntax for declaring a Variable is

data-type V1, V2, ---- Vn;

V1, V2 → names of Variables

→ Variables are Separated by comma. A declaration Statement must end with a Semicolon

Example1: int count;
int number, total;
double ratio

Datatype	Keywords
Integer	int
character	char
Signed character	Signed char
Floating-point	float
double-precision floating point	double
extended double precision floating point	long double
unsigned Integer	unsigned int

Example 2: Consider another example of Variable declarations:

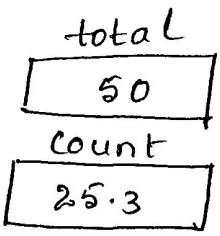
```
char a; int a, b, c
flot x y;
```

- There are 4 errors in these statements
  1) multiple declarations for variable a
  2) missing semicolon in second statement
  3) incorrect datatype flot instead of float
  4) no comma separator between x and y

Variable Initialization :-

- C Language allows us to initialize one or more variables in a declaration statement using assignment Operator "="
- The variable initialization statement takes the following form:

```
data-type Variable1 = expresssion1;
int total = 50;
float count = 25.3;
```



- C permits multiple assignments in one line

```
int total = 50, count = 60;
float total = 50.3, count = 60.2;
int p = Q = s = 0;
```

- process of giving initial values to variable is called Initialization.

Program: program to demonstrate Variable declarations, assignments & values stored in Various types of Variables.

```
#include <stdio.h>
main()
{
    float x, p;          /* declaration */
    double y, q;         /* declarations */
/* declaration and assignments */
    int m = 54321;
Long int n = 1234567890;
    /* Assignments */
    x = 1.234567890000;
    y = 8.7654321
    K = 54321
    P = q = 1.0;
/* ------ printing ------- */
printf("m = %d\n", m);
printf("n = %ld\n", n);
printf("x = %.12lf\n", x);
printf("x = %f\n", x);
printf("y = %.12lf\n", y);
printf("y = %lf\n", y);
printf("K = %u p = %f q = %.12lf\n", K, P, q);
```

Output : m = 54321
n = 1234567890
x = 1.23456789000
x = 1.2345678
y = 8.765432100000
y = 8.765432
k = 54321 p = 1.000000 q = 1.000000

Symbolic Constants :- [Defined Constants]

- Symbolic Constant or a macro is a name given to a sequence of characters using the #define preprocessor directive
- Symbolic Constants allow us to give meaningful name to literal constants & expressions making the programs more readable.
- The format of the #define statement, which is written on a line by itself, is as follows :

```
#define Symbolic_name Value of Constant.
```

- Symbolic Constants are written in uppercase to distinguish them from Variable names.
- Eg. we can define Symbolic constant PI to represent the mathematical constant π as follows

```
#define PI 3.14
```

- Once a name is defined as Symbolic constant, it can be used in rest of the program in the place of value of constant

Declaring Variable as Volatile

- The Qualifier volatile is used to tell explicitly the compiler that variable's value may be changed at any time by some external source.

Example: volatile int date;

- Here the date may be altered by external factors. when we declare variable as volatile, the compiler will examine the value of the variable each time to see whether any external alteration has changed the value.

- If we wish that value of variable must not be modified by the program while it may be altered by some other process then we may declare the variable as both const and volatile

```
volatile const int location = 100;
```

Coding constants:

Three Different ways of to code constants in our programe. They are
1. Literal constants
2. Defined constants } Discussed in
3. Memory constant } previous section

Literal constants: The constants which do not have any name are called Literal constants

```
Example: 'A'    //Character literal
         9      // Integer numeric literal
         3.1415 // floatingpoint literal
```

- During program compilation, the C preprocessor substitutes any occurance of symbolic constant name with the corresponding value.

Example:
```
#define MAX_MARKS 100
#define PI 3.1415927
```

- These statements declare 2 symbolic constants. It is easy to understand the use of names such as MAX_MARKS & PI in programs instead of constants 100 & 3.1415297 respectively

Examples of Invalid #define statements

1. `#define X = 2.5` → '=' sign is not allowed
2. `# define MAX 10` → No space between # & define
3. `#define N 25;` → No semicolon at the end
4. `#define N 5, M 10` → Statement can define only one name
5. `#define price$ 100` → $ symbol is not permitted in name
6. `#Define ARRAY 11` → define should be in lowercase letters

Declaring Variable as a Constant [Memory Constant]

- Value of certain variables remain constant during the execution of program. This can be achieved by declaring the variable with the Qualifier const at the time of initialization.

Syntax: `const datatype variable = value;`

Example: `Const int marks = 100;`

* When the accuracy provided by a float number is not sufficient, the type double can be used to define the number.
* A double data type number uses 64 bits giving a precision of 14 digits
* To extend further, we may use long double which uses 80 bits.

Void Types

* The void type has no value.
* The type of a function is said to be void when it does not return any value to the calling function.

Character Types

* Characters are usually stored in 8 bits of internal storage.
* The Qualifier signed or unsigned may be explicitly applied to char.

Size & Range of Data Types on 16-bit Machine.

	Type	Size (bits)	Range
1.	char / signed char	8	-128 to 127
2.	unsigned char	8	0 to 255
3.	int / signed int	16	-32,768 to 32,767
4.	unsigned int	16	0 to 65535
5.	short int / signed short int	8	-128 to 127
6.	unsigned short int	8	0 to 255
7.	long int / signed long int	32	-2,147,483,648 to 2,147,483,6
8.	unsigned long int	32	0 to 4,294,967,295
9.	float	32	3.4E-38 to 3.4E+38
10.	double	64	1.7E-308 to 1.7E+308
11.	long double	80	3.4E-4932 to 1.1E+4932

Enumerated data type

* It is a user-defined data type provided by ANSI standard

General syntax : enum identifier { value1, value2, ---- valuen);

* This user defined data type is used to declare variables that can have one of the values enclosed with in the braces (known as enumeration constants)

* After this definition we can declare variables to be of this 'new' type as follows

enum identifier v1, v2, ... vn;

The enumerated variables v1, v2 --- vn can have only have one of the values value1, value2, --- valuen

Example: enum day { Monday, Tuesday, ----- Sunday};
enum day week_st, week_end;
week_st = Monday;
week_end = Friday;
if (week_st == Tuesday)
week_end = Saturday;

* Compiler automatically assigns integer digits beginning with 0 to all enumeration constants. i.e value1 is assigned 0, value2 is assigned 1 & so on.

* Automatic assignments can be overridden by assigning values explicitly to enumeration constant.

enum day { Monday = 1, Tuesday, ---- Saturday);

Here constant monday is 1 & remaining constants are assigned values that increases successively by 1.

Appendix-2 : User-Defined Type Declaration
Declaration of storage class

User-Defined Type Declaration

- C supports a feature known as "type definition" that allows users to define an identifier which represents an existing data type
- The user defined datatype identifier can later be used to declarare variables.

General Syntax: `typedef type identifier;`
- `type` → existing datatype
- `identifier` → new name given to data type

Example:
```
typedef int units;
typedef float marks;
```

Here units symbolizes int & marks symbolizes float. They can be later used to declare variables as follows

```
units batch1, batch2;
marks name1[20], name2[20];
```

Here batch1 and batch2 are declared as int variables & name1[20] and name2[20] are declared as floating point array variable

Advantage : We can create meaningful datatype names for increasing the readability of the program

program to demonstrate the usage of coding constants in C

```
#include<stdio.h>
#define PI 3.1416
Void main()
{
   const float Pi = 3.1416
   Printf("Literal constant : %f\n", 3.1416);
   Printf("Defined constant : %f\n", PI);
   Printf(" Memory constant: %f\n", Pi);
}
```

Input and Output Functions

Input and output functions.

Input functions

- Input functions accept the data from the keyboard and store in memory locations. These functions help the user to input the data from input devices. such as keyboard & transfer data to memory locations

Ex: scanf, getch(), getche(), getchar(), gets()

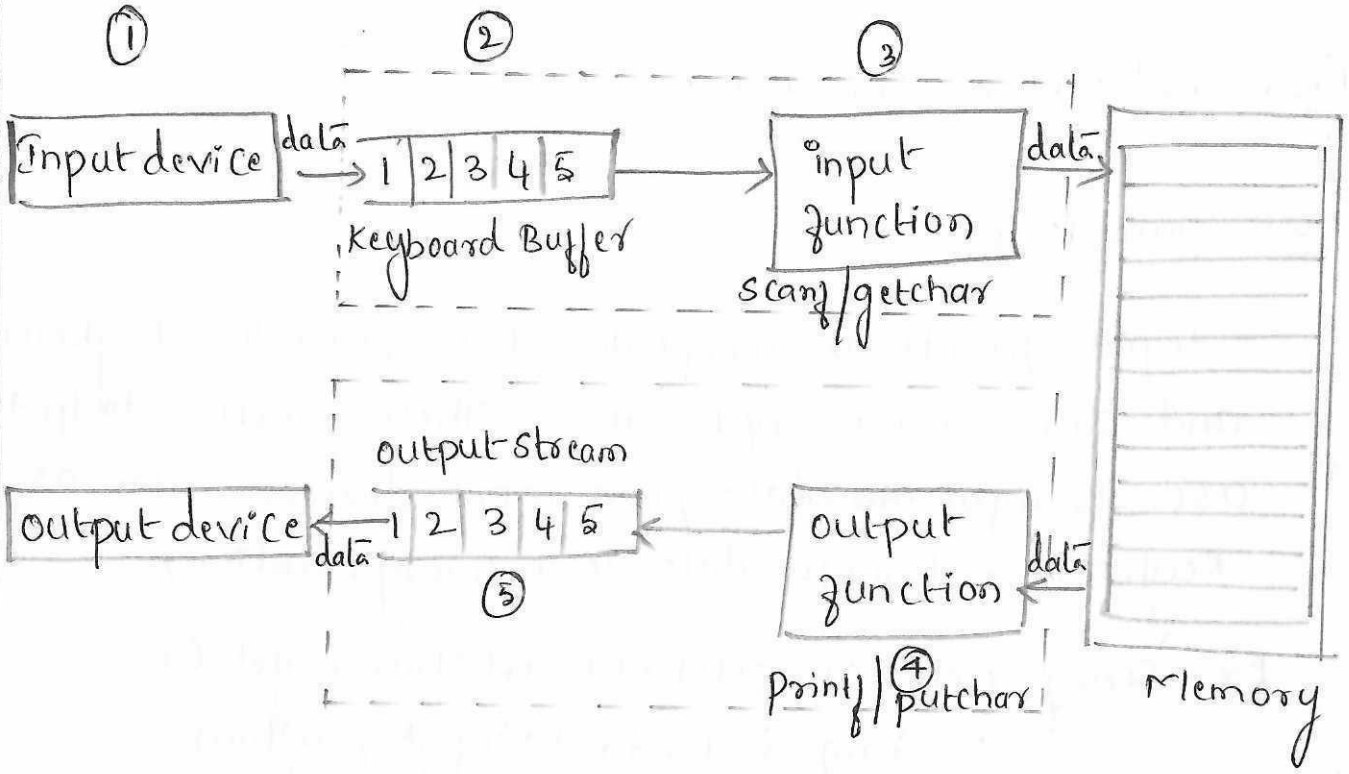
scanf → Standard Input function
keyboard → Standard input device

Output functions

- Output functions receive data from memory locations and display on the monitor.
- These functions that help the user to send the data stored in memory locations to output devices such as monitor or printer are called output function.

printf → Standard output function
monitor → Standard output device

Ex: printf(), putch(), putchar(), puts()



① Data is entered from the keyboard

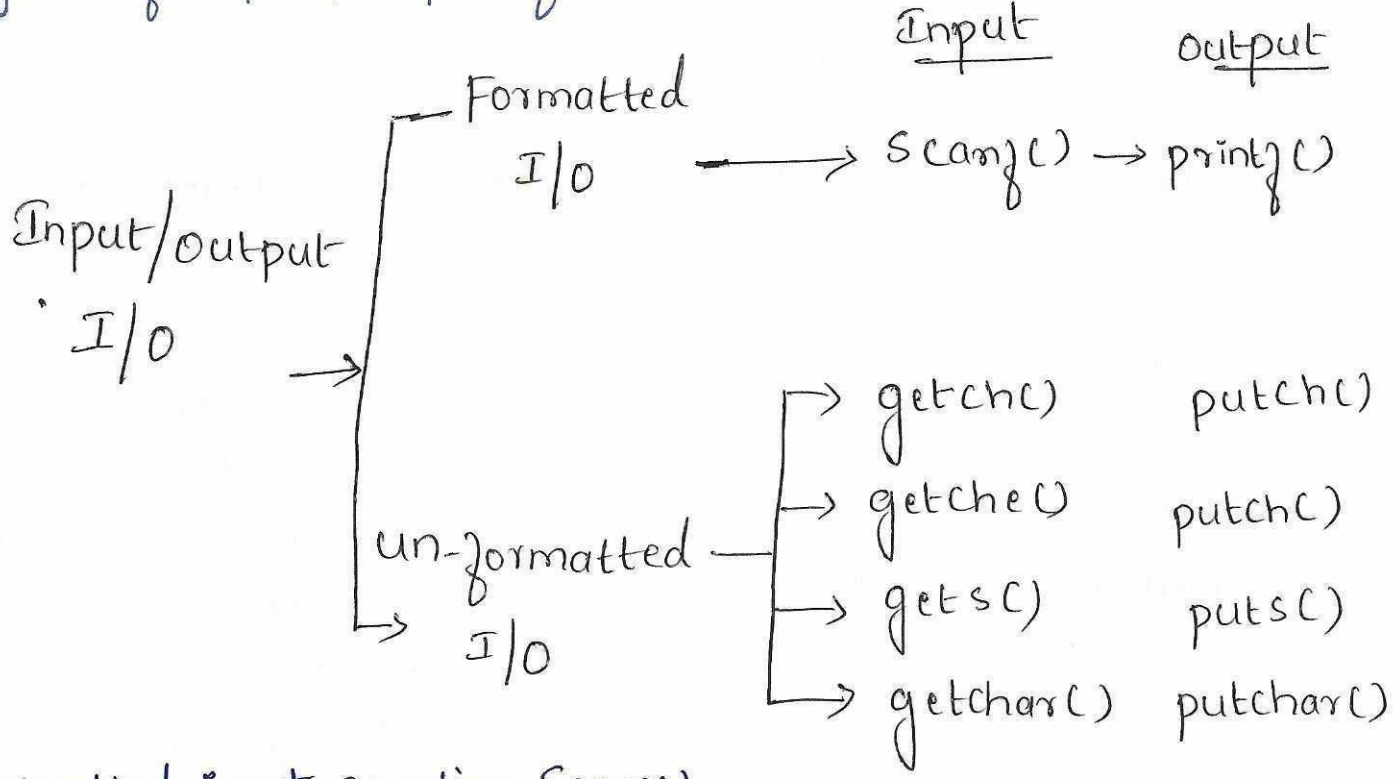
② Data entered is stored in temporary storage area called keyboard buffer. Buffer holds the data until we press enter

③ using input function such as scanf/getchar(), data stored in the keyboard buffer is read & data is converted into appropriate data type. Converted data is stored in memory locations using variables.

④ using output function, data is read from memory and stored in temporary storage area called as screen buffer/output stream

⑤ Data available in the screen buffer is visible on the screen.

Types of Input/output functions



Formatted input function Scanf()

* The function scanf() stands for scan formatting & is used to read formatted data from the keyboard

* This function takes a text stream from the keyboard, extracts & formats data from the stream according to a format control string & then stores the data in specified program variables.

Syntax: `scanf("format control string", address list);`

Example: `scanf("%d", &x);`

-> format control string is enclosed within 2 Quotations "" ... "" & contain 1 or more format specifiers

-> format specifier starts with % sign followed by conversion code

Ex: `scanf("%d %f %c", &x, &y, &z);`

Format Specifiers

Data type	format specifier	Description
int	%d	converts data into decimal signed integer
unsigned int	%u	Converts data into unsigned integer
long int	%ld	converts data into long interger value
short int	%hd	converts data into short integer
float	%f	Converts data into floating point value
char	%c	converts data into character
double	%lf	Converts data into long floating point no. or double
String	%s	Converts sequence of characters into strings

Note: Space, comma etc are allowed in between format specifiers.

Rules for scanf()

1. There must be format specifier for each variable i.e no. of format specifiers must be equal to no. of variables. Eg: scanf("%d%f%c", &a, &b, &c)
   1 + 1 + 1 = 3
   1 + 1 + 1 = 3
2. Variables present in scanf must represent address of memory locations. Eg: scanf("%d", &a);

3. The type conversion specified in each format specifier must match with corresponding type of variable present

Eg: int a;
scanf("%d", &a);
↓ integer
↳ integer variable

4. White space characters i.e \t, \b, \n should not be used in scanf.

5. process of converting the data into appropriate data type will be stopped whenever
   1. end of file is encountered.
   2. maximum no. of characters have been processed
   3. an error is detected in the input.

Formatted output function printf()

→ As the name indicates, it does two functions.

1. print → This function prints the data stored in specified memory locations [variables]
2. Format → The data present in memory locations [variables] is read & converted into appropriate data type which is done using format string with the help of conversion codes.

Syntax : printf("format string", list of variables);

Example : printf("%d %f %c", x, y, z);

printf("HELLO"); // text is being displayed

* printf("%d\n%d\n");

→ If a=10 b=10

printf("%d\n%d", a, b);

Output: 10
10

→ If a=10 b=20

printf("%d\t%d", a, b)

output 10. 10

Note: Delimiters such as space, comma, etc are allowed in between format specifiers along with any of backslash characters

Field width Specifications for integers

* printf() function uses the field width to know the number of columns (spaces) used on the screen while printing a value.

Syntax: %wc

↳ indicates precision which represents total number of columns required to print the value

c → c is the conversion character such as d for decimal integer, f for floating point number, lf for long float or double etc.

Example: int a=798

```
printf("%5d\n", a);
printf("%-5d\n", a);
printf("%2d", a);
```

1) %5d indicates reserve 5 columns & display the value of a in right justified manner

2) %-5d indicates reserve 5 columns & display the value of a in left justified manner

3) %.2d indicates reserve 2 columns, But we are printing data 798 with 3 digits. In such situations printf will override the width.

output:

	1	2	3	4	5
1			7	9	8
2	7	9	8		
3	7	9	8		

Field width specification for float:

Syntax: %mw.xf

f → Converts sequence of characters into floating point value

x → number of digits to be printed after dot

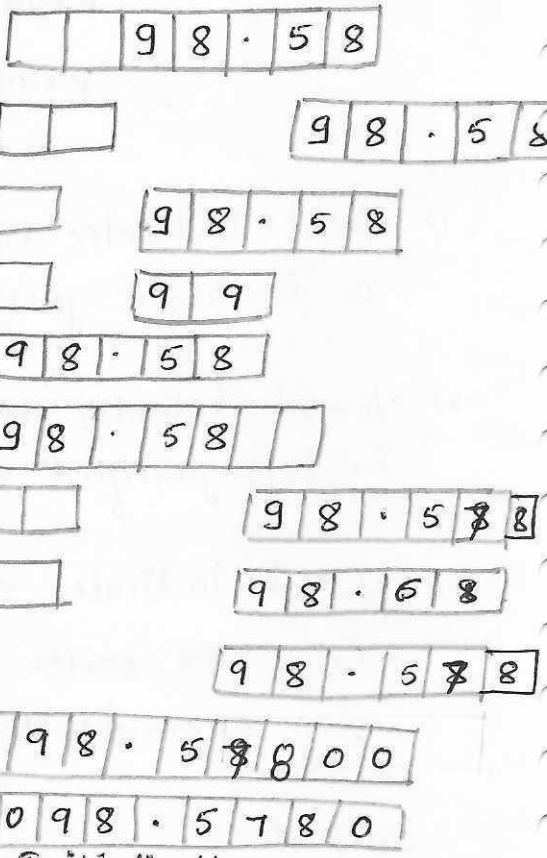
w → w is the width i.e total number of spaces required to print the data

m → It is symbol. (-) indicates left justified

if symbol is not present then it is right justified

Example: float = 98.578

```
printf("%7.2f\n", a);
printf("%2.2f\n", a);
printf("%1.3f\n", a);
printf("%1.0f\n", a);
printf("%0.2f\n", a);
printf("%-7.2f\n", a);
printf("%2.3f\n", a);
printf("%1.1f\n", a);
printf("%0.3f\n", a);
printf("%9.5f\n", a);
printf("%09.4f\n", a);
```



Example 2 : Consider the following Initialization

```
int a=10;
float b=15.5;
```

write a printf statement to display a message

"LARGEST(10, 15.5) = 15.5"

Sol": printf("LARGEST(%d, %f) = %f", a, b, b);

unformatted Input/output functions

unformatted Input functions

* The unformatted input functions are as given below

1. getchar()
2. getch()
3. getche()
4. gets()

1. getchar()

- whenever we want to read a character from the keyboard and store it into a memory location locatio getchar() function is used. press enter key after typi a characte

Syntax: ch=getchar();

```
#include<stdio.h>   (conio.h)
Void main()
{
    Char ch;
    ch=getchar();
    putchar(ch);
}
```

Input

P↵

Output

P

2. getch()

- whenever we want to read a character from the keyboard without echo (typed character will not be displayed on the screen) we use getch() function.

Syntax: ch=getch();

Note: typed character will not be displayed on screen

```
#include<stdio.h>   (conio.h)
Void main()
{
    char ch;
    ch=getch()
    putch(ch);
}
```

Input: A (character will not be visible)

output: A

3. getche()

- whenever we want read a character from the keyboard with echo (typed character will be visible on the screen), we use getche() function.

Syntax: ch = getche();

```
#include<conio.h>
void main()
{
    char ch;
    ch= getche()
    putch(ch);
}
```

Input : A

Output : A

4. gets()

- whenever we want to read a sequence of characters from the keyboard with spaces inbetween & store them in memory location.

Syntax: gets(str);

```
#include<stdio.h>
void main()
{
    char str[10];
    gets(str);
    puts(str);
}
```

input

A BC↵

output

A BC

Unformatted output functions:

unformatted output functions are

1. putchar()
2. putch()
3. puts()

1. putchar()

- whenever we want to display a character stored in the memory on the screen, putchar() function is used.

Syntax: putchar(ch);

2. putch()

- To display a character stored in memory location on the screen, putch() is used

Syntax: putch(ch);

3. puts()

- To display a sequence of characters stored in memory locations on the screen, puts() is used

Syntax: puts(str);

Library / pre-defined functions

- C library that comes with C compiler has a collection of various functions which perform standard & pre-defined tasks. These are
- These functions are written by manufacturers of C compilers are called Library functions.
- Different types of libraries are given below

1. Math Library :-

Eg: sqrt(d), pow(d1, d2), log(d), sin(d), cos(d) etc.

defined in math.h #include<math.h>

2. Standard Library :-

1. exit()
2. malloc()
3. calloc()
4. rand()
5. abs()
6. free() etc.

Defined in #include<stdlib.h>

3. Character Library :-

1. isalpha(i)
2. isdigit(i)
3. islower(i)
4. isupper(i)
5. tolower(i)
6. toupper(i)

Defined in #include<ctype.h>