

**Module 1:**

**Introduction to C: Introduction to computers, input and output devices, designing efficient programs. Introduction to C, Structure of C program, Files used in a C program, Compilers, Compiling and executing C programs, variables, constants, Input/output statements in C,**

**Textbook: Chapter 1.1-1.9, 2.1-2.2, 8.1 - 8.6 ,9.1-9.14**

**What is Computer?**

- Computer is an electronic device, which takes input from the user in the form of data and instructions.
- Once the computer receives the data, it waits for the user's instructions to process the data.
- On receiving the instructions from the user, the computer processes the data and generates the output and displays it to the user.
- The data that is given as an input to the computer can be text, numerals, audio, video and image etc

**In simple terms computer can be defined as,**

**“An electronic device which accepts the data, performs the required mathematical and logical operations at high speed and outputs the result”.**

**Tasks of the Computer:**

- **Input:** Sending the data and command to the computer is known as input.
- **Processing:** Work done by the computer with the help of processing hardware and software to produce results is known as processing.
- **Output:** The result displayed by the computer is called as output.
- **Storage:** A place to save results inside or outside the computer is known as storage.

**Characteristics of computers:**

- **Speed:** Computers can perform millions of operations per second. The speed of computers is usually given in nanoseconds/picoseconds where  $1\text{ns} = 1 \times 10^{-9}$  seconds and  $1\text{ps} = 1 \times 10^{-12}$  seconds

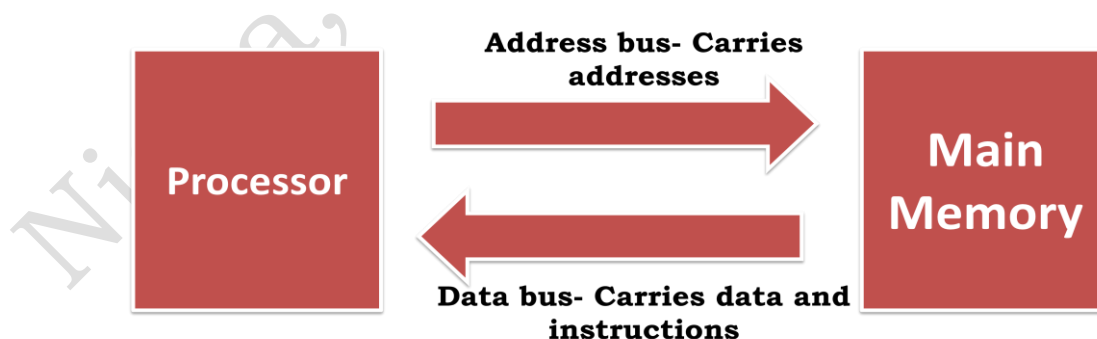
- **Accuracy:** A computer can always give accurate results, provided the correct input and instructions as input. If the input is wrong, then output will be erroneous. This is called “**garbage-in, garbage-out**”
- **Automation:** Computers performs the task without any human intervention.
- **Diligence:** Unlike humans, computers never get tired of repetitive task.
- **Versatile:** Computers can perform multiple tasks of different nature at the same time.
- **Memory:** Computers have internal or primary memory and External or Secondary memory to store data and programs.
- **No IQ:** Computers do not have any decision making abilities of their own. They need guidance to perform various tasks.
- **Economical:** Computers are considered as short tem investment for achieving long term gains. They save time, money and energy.

#### What is difference between data and information?

- **Data is a raw fact.**
- **Information is a processed data.**

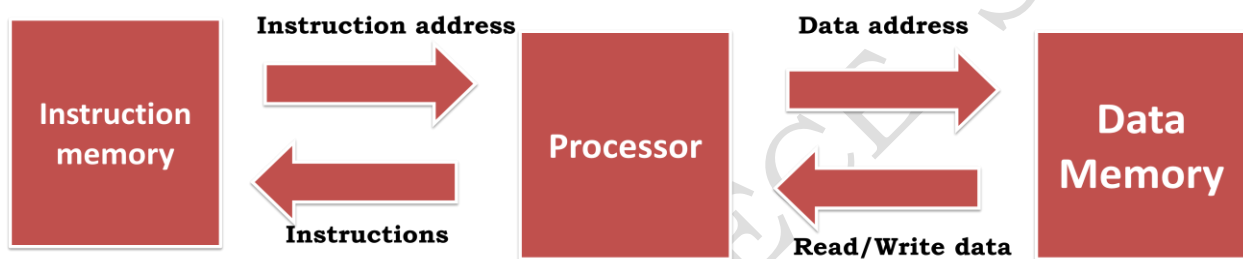
For example, the date of birth is the data and calculating the age using date of birth is information.

#### Types of stored program Computers



**Fig: Von Neumann Architecture with shared memory for instructions and data**

- A computer with Von Neumann Architecture stores data and instructions in the same memory.
- There is a serial machine in which data and instructions are selected one at a time.
- Data and instructions are transferred to and from memory through shared data bus.
- Since there is a single bus to carry data and instructions, process of execution becomes slower.



**Fig: Von Neumann Architecture with separate memory for instructions and data**

- Due to the disadvantage of previous architecture, Harvard University proposed a stored program concept in which there was a separate memory to store data and instructions.
- Instructions are selected serially from the instruction memory and executed in the processor.
- When an instruction needs data, it is selected from the data memory and hence the execution becomes faster.

### **History of Computers:**

#### **First Generation (1942-1955): Vacuum Tubes**

- These computers were manufactured using thousands of vacuum tubes.
- The Electromagnetic relay was used as primary memory and punch cards were used to store data and instructions.

- Programming was done in machine or assembly level language.

**Advantage:**

Fastest calculating devices of their time.

**Disadvantage:**

Generated lot of heat, Consumed lot of electricity, Bulky in size, required constant maintenance, Limited commercial use and very expensive.



**Vacuum tubes**

**Second Generation (1955-1964): Transistors**

- These computers were manufactured using transistors which were reliable, cheaper, smaller and cooler than vacuum tubes.
- Magnetic core memory was used as primary memory and magnetic tapes and disks were used to store data and instructions.
- Programming was done in high level programming language.



Transistors

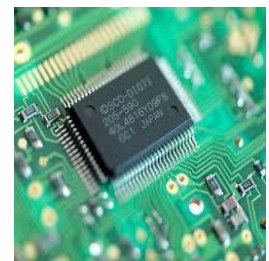
**Transistors**

**Advantage:** Consumed less electricity, Generated less heat, Faster cheaper and more reliable, could be programmed using high and assembly level language, had faster primary memory and larger secondary memory.

**Disadvantage:** Transistors were assembled manually which made commercial production difficult and expensive

**Third Generation (1964-1975): Integrated circuits**

- These computers were manufactured using transistors integrated chips(IC's) which consists of several components such as transistors, capacitors and resistors on single chip to avoid wired connections between components.



**Integrated Circuits**

- Large Magnetic core memory was used as primary memory and magnetic tapes and disks were used to store data and instructions.
- Programming was done in high level programming language.

**Advantage:** Faster and could perform one million transactions per second, Smaller, cheaper and more reliable, Faster and larger primary and secondary memory, widely used for scientific and business applications

**Disadvantage:** Difficult to maintain and got heated very quickly.

#### **Fourth Generation (1975-1989): Microprocessors**

- These computers were manufactured using transistors integrated chips(IC's) with LSI's and later with VLSI.
- Semiconductors memory was used as primary memory and magnetic tapes and floppy disks were used as portable storage devices.
- Programming was done in high level programming language such as C and C++.

**Advantage:** Smaller, cheaper, faster and more reliable, Consumer less electricity, generated less heat, Used as General purpose computers, GUI's made work with computer easier, Widespread of computers to office and homes

**Disadvantage:** Not intelligent systems.

#### **Fifth Generation (1989-Present): Artificial Intelligence**

- These computers were manufactured using transistors integrated chips(IC's) with ULSI's(Ultra Large scale Integration) technology.
- Semiconductors memory was used as primary memory and magnetic tapes and floppy disks were used as portable storage devices.
- Programming was done in high level programming language such as Java, Python,

C#.

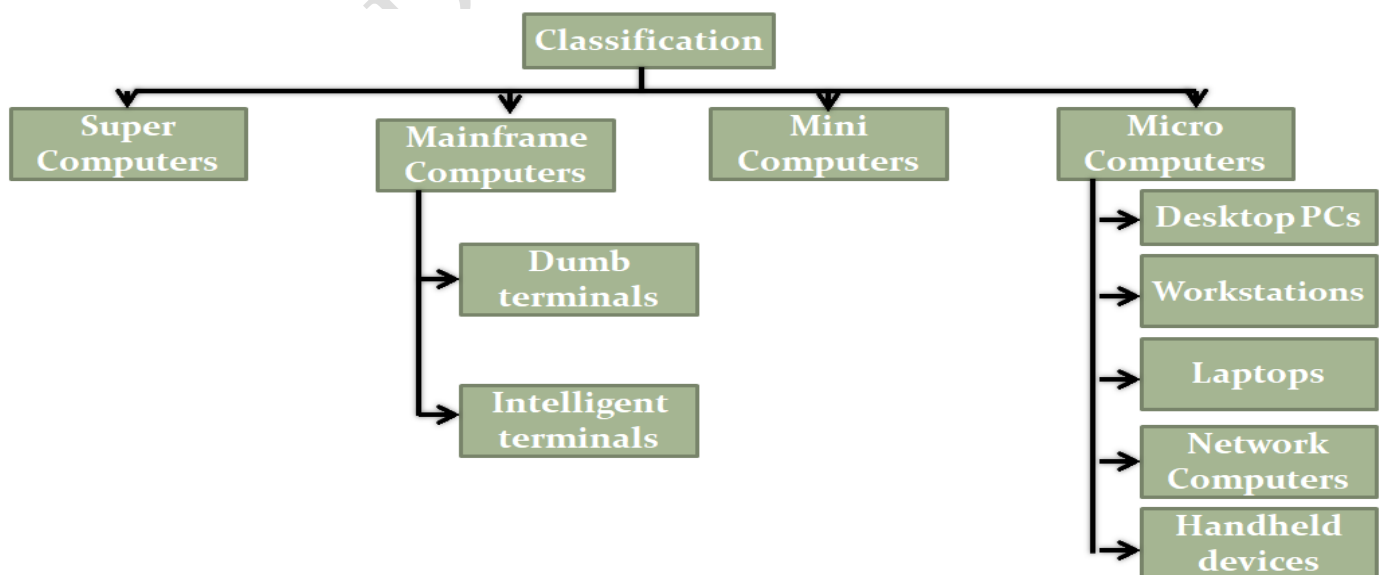
**Advantage:**

Smaller, cheaper, faster, powerful and more reliable, Consumer less power, generated less heat, high-end features available.

**Comparison table**

-	Year	Manufactured using	Primary memory	Storage device
<b>First generation</b>	1942-1955	Vacuum tubes	Electromagnetic relay	Punch cards
<b>Second generation</b>	1955-1964	Transistors	Magnetic Core Memory	Magnetic tapes and disks
<b>Third generation</b>	1964-1975	IC's	Large Magnetic Core Memory	Magnetic tapes and disks
<b>Fourth generation</b>	1975-1989	Microprocessor	Semiconductor memory	Magnetic tapes and floppy disks
<b>Fifth generation</b>	1989-Present	AI	Semiconductor memory	Magnetic tapes and floppy disks

**Classification of Computers:**



1) **Supercomputers:**

- It is the fastest, most powerful, and most expensive computer.
- It was first developed in 1980s to process large amounts of data and solve complex scientific problems.
- They use parallel processing technology and can perform trillion calculations in a second.
- A single supercomputer can support thousands of users at same time.
- They are used for weather forecasting, nuclear energy research, aircraft design, automotive design, online banking etc.
- Examples of supercomputers are: CRAY-1, CRAY-2, ETA A-10.

2) **Mainframe Computers:**

- They are large scale computers but smaller than supercomputers.
- These are very expensive and need a very large clean room with air conditioning, making them very costly to deploy.
- Mainframes can also support multiple processors.

**Dumb terminals:**

It consists of only monitor and keyboard and uses mainframe's system CPU and storage device.

**Intelligent terminals:**

It have their own processor and perform processing operations but do not have their own storage space.

- Mainframe computers are typically used as servers on WWW.

- They are also used in organizations such as banks, airline companies, universities where large number of people access the data frequently.
- Examples of Mainframe computers are: IBM S/390, Control Data CYBER 176, and Amdahl 580.

### 3) **Minicomputers:**

1. They are smaller, cheaper, and slower than mainframes.
2. They are also called Midrange computers.
3. The capabilities of these fall between mainframe and personal computers.
4. They are widely used in business, education, hospitals, government organizations, etc.
5. Some minicomputers are designed in such a way that it can be either used by single user or multiple users.
6. Single-user minicomputers are used for performing complex design tasks.
7. The first Minicomputer was introduced by Digital Equipment Corporation in mid-1960's.

### 4. **Microcomputers:**

- They are commonly known as PC's.
- The first microcomputer was designed by IBM in 1981 and was named as IBM-PC.

#### **Desktop PCs:**

- It is the most popular model of PC's.

#### **Laptops:**

- They are small microcomputers that easily fit inside a briefcase.



- The memory and storage capacity of a laptop is almost equivalent to a desktop computer.
- They also have hard disk drives.
- For input, laptops have built-in keyboard and touch pad.

**Workstations:**

- A workstation is nothing but a computer like a personal computer, but with more powerful microprocessor and large, high resolution monitor for better quality of pictures along with large amount of memory.

**Advantages:** High Resolution, Accelerated graphics cards- they are used in video editing and animations, Powerful machines and used for architectural or engineering design.

**Disadvantages:** Workstations are costly, Not Portable.

**Network computers:**

- Network computers have less processing power, memory, and storage than a desktop computer.
- These are specially designed to be used as terminals in a networked environment.
- For example, some network computers are specifically designed to access data stored on a network (including the Internet and intranet).
- Some network computers do not have any storage space and merely rely on the network's server for data storage and processing tasks. The concept of network computers had become popular in the mid-1990s
- Network computers that are specifically designed to access only the Internet or intranet are often known as Internet PCs or Internet boxes.

- Some network computers used in homes do not even have a monitor. Such computers may be connected to a television, which serves as the output device.
- The most common example of a home-based network computer is Web TV, which enables the user to connect a television to the Internet.
- The Web TV is equipped with a special set-top box that is used to connect to the Internet.
- The set-top box also provides controls to enable the user to navigate the Internet, send and receive e-mails, and to perform other tasks on the network while watching television.
- The other reason for the popularity of network computers is that they are cheaper to purchase and maintain than PCs.

**Smart phones:**

- A smart phone is an electronic hand held device that has the functionality of a mobile phone and PDA.
- This is achieved by adding mobile phone features to an existing PDA.

**Advantages:**

- Various software applications such as E-Mail, SMS, voice recognition, camera, etc..
- It can be connected to internet for web browsing.
- Can be used to listen to music or radio.
- PC Compatibility.

**Disadvantages:** Generally larger than standard handsets, More expensive, High replacement cost.

### **Tablet Computers:**

- A tablet PC is a personal computer and looks like a standard slate.
- The display system can be rotated by 180 degree.
- It has all the features of a laptop and allows the user to write on the screen using digital pen. This pen is called stylus. This pen is also used to tap on the icon so as to select an item.

### **Advantages:**

- Notes can be written using our handwriting style.
- Paper work can be eliminated.
- They are very slim and light weight compared to laptops and hence they are portable.

**Disadvantages:** • They are costlier and delicate. • High replacement cost

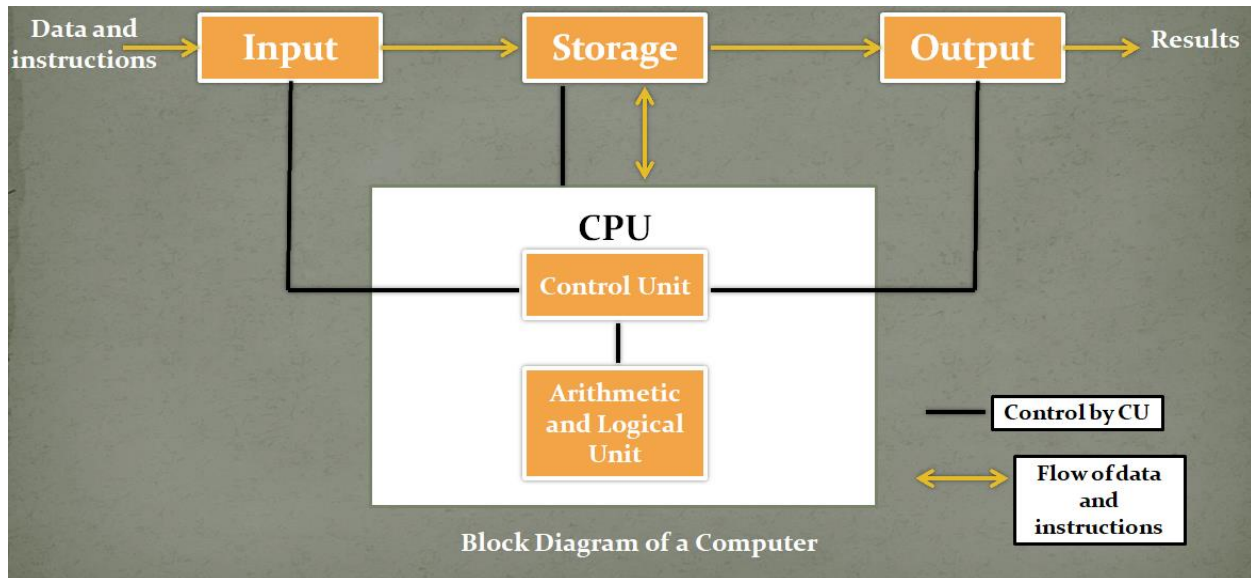
### **Applications of Computers:**

1. **Word Processing:** Word Processing software enables user to read and write documents.
2. **Internet:** The internet is a network that connects the computers all over the world.
3. **Digital video or Audio Composition:** Computers make Audio and Video editing very simple.
4. **Desktop publishing:** This software enables to create page layouts for entire books.
5. **E-Business:** It is a process of conducting business via Internet.
  - Business-to-Consumer or B2C: The term business-to-consumer (B2C) refers to the process of selling products and services directly between a business and consumers who are the end-users of its products or services.

- Business-to-Business or B2B: Business-to-business (B2B) is a transaction or business conducted between one business and another, such as a wholesaler and retailer.
  - Consumer-to-Consumer or C2C: It's a business model that fosters commerce between private individuals, usually in an online environment.
  - Electronic banking: Also known as Cyber banking or online banking which supports various banking activities conducted from home, business instead of physical bank location.
- 6) **Bioinformatics:** Bioinformatics is an interdisciplinary field of science that develops methods and software tools for understanding biological data, especially when the data sets are large and complex.
- 7) **Health care:** In health care, it is used to store health records, surgical procedures for better diagnosis and treatment.
- 8) **Geographic Information System and Remote Sensing:** It is a computer based tool for mapping and analyzing Earth's features.
- 9) **Meteorology:** It is the study of atmosphere.
- **Weather Forecasting:** It includes application of science and technology to predict the state of atmosphere for a future time and given location.
  - **Aviation meteorology:** It studies the impact of weather on air traffic management.
  - **Agricultural meteorology:** It deals with the study of effects of weather and climate on plant distribution, crop yield, water use efficiency, plant and animal development.
  - **Nuclear meteorology:** It deals with the study of distribution of radioactive aerosols and gases in the atmosphere.
  - **Maritime meteorology:** It deals with the study of air and wave forecasts for ships operating at sea.

- 10) **Multimedia and Animation:** which combines still images, moving images, text, sound.
- 11) **Legal System:** Computers are used by lawyers to shorten the time required to conduct legal precedent and case research.
- 12) **Retail Business:** Computers are used here to enter orders, calculate costs, and print receipts.
- 13) **Sports:** Computers are used here to compile statistics, identify weak and strong players, sell tickets etc.
- 14) **Travel and Tourism:** Computer are used to prepare tickets, monitor the train or airplane route, and guide the plane to a safe landing.
- 15) **Simulation:** Supercomputers that can process enormous amount of data are widely used in simulation tests.
- 16) **Astronomy:** Spacecrafts are usually monitored using computers that not only keep a continuous record of the voyage and of the speed, directions, fuel and temperature, but also suggest corrective actions when vehicle make a mistake.
- 17) **Education:** Teachers use computers to develop instructional material.
- 18) **Industry and Engineering:** Computers are found in all kind of industry like thermal power plants, oil refineries, chemical industry, Computer-aided designing, Computer aided manufacturing.
- 19) **Decision support systems:** Computers help managers to analyze their organization data to understand the present scenario of the business.
- 20) **Expert systems:** Expert systems are used to automate the decision-making process in a specific area, such as analyzing the credit histories for loan approval, diagnosing a patient's condition for prescribing an appropriate treatment.

## Basic Organization of Computers



### What does a computer do?

A computer is an electronic device which performs 5 major operations.

- Accepting data or instructions.
- Storing data
- Processing data
- Displaying results
- Controlling and coordinating all operations inside a computer.

### Input:

- The process of entering the data and instructions into the computer system is called Input.
- The data and instructions can be entered by using different input devices such as keyboard, mouse, scanner, and trackball.

- Note that computers understand binary language, which consists of only two symbols (0 and 1), so it is the responsibility of the input devices to convert the input data into binary codes.

**Storage:**

- Storage is the process of saving data and instructions permanently in the computer so that they can be used for processing.

- A computer has 2 types of storage area:

1. Primary storage
2. Secondary storage

**1. Primary storage:**

- Primary storage, also known as the main memory, is the storage area that is directly accessible by the CPU at very high speeds.
- It is used to store the data and parts of programs, the intermediate results of processing, and the recently generated results of jobs that are currently being worked on by the computer.
- Primary storage space is very expensive and therefore limited in capacity.
- Another drawback of main memory is that it is volatile in nature; that is, as soon as the computer is switched off, the information stored gets erased.
- Hence, it cannot be used as a permanent storage of useful data and programs for future use. An example of primary storage is random access memory (RAM).

**2. Secondary storage:**

- Secondary storage is also known as auxiliary memory, this memory is just the opposite of primary memory. It overcomes all the drawbacks of the primary storage area.

- It is cheaper, non-volatile, and used to permanently store data and programs of those jobs that are not being currently executed by the CPU.
- Secondary memory supplements the limited storage capacity of the primary memory. An example is the magnetic disk used to store data, such as C and D drives, for future use.

**Output:**

- Output is the process of giving the result of data processing to the outside world (external to the computer system).
- The results are given through output devices such as monitor, and printer.
- Since the computer accepts data only in binary form and the result of processing is also in binary form, the result cannot be directly given to the user.
- The output devices, therefore, convert the results available in binary codes into a human-readable language before displaying it to the user.

**Control :**

- The control unit (CU) is the central nervous system of the entire computer system. It manages and controls all the components of the computer system.
- It is the CU that decides the manner in which instructions will be executed and operations performed. It takes care of the step-by-step processing of all operations that are performed in the computer.
- Note that the CPU is a combination of the arithmetic logic unit (ALU) and the CU. The CPU is better known as the brain of the computer system because the entire processing of data is done in the ALU, and the CU activates and monitors the operations of other units (such as input, output, and storage) of the computer system.



**Processing:**

- The process of performing operations on the data as per the instructions specified by the user (program) is called processing.
- Data and instructions are taken from the primary memory and transferred to the ALU, which performs all sorts of calculations.
- The intermediate results of processing may be stored in the main memory, as they might be required again.
- When the processing completes, the final result is then transferred to the main memory.
- Hence, the data may move from main memory to the ALU multiple times before the processing is over.

**Inside the Computers**

**CPU:**

- The CPU is the brain of the computer. It performs all calculations and controls the devices connected to the computer system.
- The faster the CPU, the quicker programs can process the instructions.

**RAM:**

- A fast CPU is of no use if the computer does not have sufficient RAM.
- RAM is the computer's memory which stores information used by applications that are currently being executed by the CPU.
- More memory means more applications can be executed at the same time without degrading the system's performance.

**Hard disk drive (HDD) :**

- The HDD of the computer is the secondary memory of the computer system where information is stored permanently.
- All types of data, documents, and programs are stored on the hard disk.
- The larger the hard disk, the more the amount of data that can be stored on the drive.
- Though the size of the HDD does not affect the speed of execution of the program, it does affect the speed at which the user can access his/ her files.

**Video card:**

- The video card is a board that plugs into the motherboard of the computer and generates images for display.
- Many video cards these days have their own RAM and processor to enhance the speed of the graphics display.
- Many computers come with an in-built video chip.
- In such a computer, a separate video card is used only if the computer has to be used for high-end multimedia work or to play video games.

**Sound card:**

- As with video cards, sound cards are expansion boards that are used to enable a computer to manipulate sound.
- For example, sound cards allow the users to plug in speakers and a microphone. Some sound cards also provide the jacks for hooking your computer up to a common stereo.
- These days, many computers come with a built-in sound chip, which makes it unnecessary to buy a separate card unless a higher quality of sound is needed.

**Modem:**

- A modem (modulator-demodulator) is a device that enables the computer to use a telephone line to communicate and connect to the Internet.

**Network card:**

- A network card is used to connect the computer either to other computers or to the Internet (in case you are using a fast Internet connection such as cable or DSL).

**Fans:**

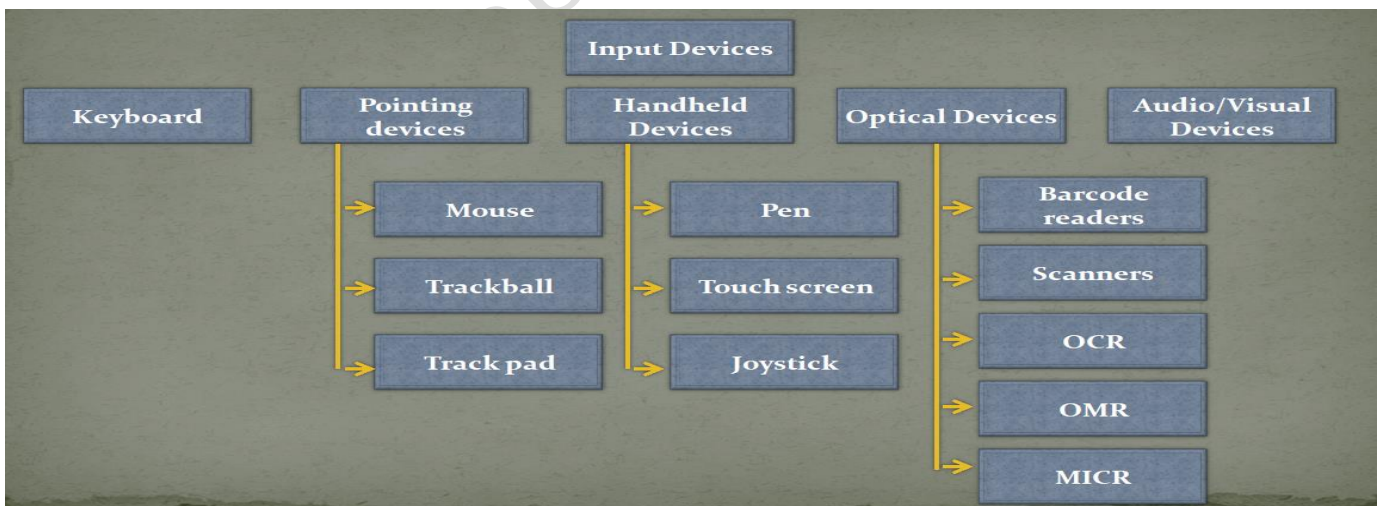
- There are one or more fans inside the computer to keep the air moving and the computer cool.

**Cables:**

- There are multiple wires inside the computer that are flat, ribbon-like cables.
- They are used to provide power and communication to the various parts inside the computer.

**Input and Output Devices**

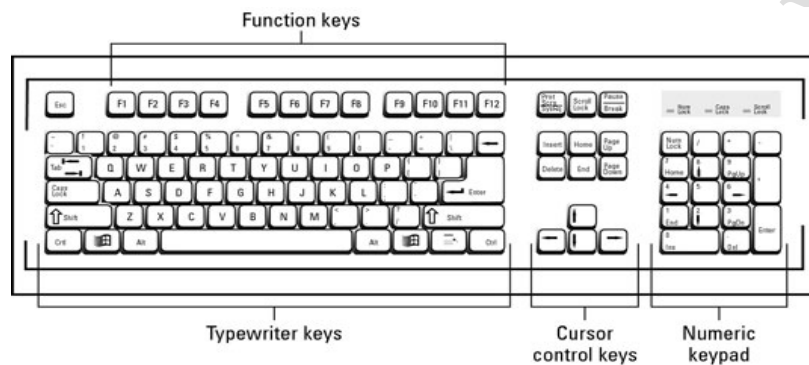
**Input devices:**



**Keyboard:**

- A keyboard is the main input devices to the computer.

- A keyboard looks like a typewriter.
- A numeric keypad is located to the right of the keyboard. Numeric keys have the same placement as a 10-key calculator, which allow the operator to enter numbers rapidly.
- Keyboard also contains other types of keys such as typewriter keys, function keys, cursor control keys, page-up and page-down keys, home and end keys, caps lock, shift etc.



### **Advantages:**

- The Keyboard is easy to use and inexpensive.

### **Disadvantages:**

- The keyboard cannot be used to draw figures.
- The process of moving the cursor to another position is very slow. Mouse and other pointing devices are more apt for this purpose.

### **Pointing devices:**

- A pointing input device enables the users to easily control the movement of the pointer to select items on a display screen, to select commands from commands menu, to draw graphics, etc.
- Some examples of pointing devices include mouse, trackball, light pen, joystick, and touchpad.

**Mouse:**

- The mouse is an input device that was invented by Douglas Engelbart in 1963.
- It is the key input device used in a graphical user interface (GUI).
- Mouse is a hand held device that allows a user to control the computer without typing instructions from the keyboard.
  - Point: Placing the pointer over the word or the object on the screen by moving the mouse on the desk is termed as pointing.
  - Drag: Dragging means pointing to a desired location while pressing the left button.
  - Click: Pressing either the left or the right button of the mouse is known as clicking. Clicking a mouse button initiates some action; for example, when you click the right button by pointing the mouse on a word, a menu pops up on the screen. When you move the pointer over the icon of an application, say Internet Explorer, and double-click on it, then it opens that application for you.
  - Scroll: The scroll wheel, which is placed in between the left and right buttons of the mouse, is used to vertically scroll through long documents.

The mouse is specially used to create graphics such as lines, curves, and freehand shapes on the screen. It is connected to a serial or a universal serial bus (USB) port on the system unit. Some of the popular mouse types are as follows:

1. Mechanical mouse
2. Optical mouse
3. Cordless mouse

**1. Mechanical mouse**

- This type of mouse has a rubber or metal ball at its bottom and an electronic circuit containing sensors.
- When the mouse is moved over a flat surface, the sensors detect the direction of movement of the ball.
- The electronic circuit translates the movement into signals and feeds it as input to the computer.

2. **Optical mouse:** The optical mouse is more advanced than the mechanical mouse. It contains a ball inside. The movement of the mouse is detected using laser technology, by using optical sensors.

3. **Cordless mouse:** A cordless or wireless mouse is not connected to the computer. The movement of the mouse is detected using radio waves or infrared light waves.

**Advantages:**

- Low Priced
- Easy to use and can be used to quickly place the cursor.

**Disadvantages:**

- Needs extra desk space to be placed and moved easily.
- The ball in the mechanical mouse must be cleaned to remove dust from it

**Trackball:**

- A trackball is a pointing device that is used to control the position of the cursor on the screen.
- It is usually used in notebook computers, where it is placed on the keyboard

**Advantages:**

- Provides better resolutions.
- Occupies less space.
- Easier to use as compared to mouse as its use involves less hand and arm movements.

**Disadvantages:** The trackball chamber is often covered with dust and must be cleaned regularly.

**Touchpad:**

- A touchpad (or trackpad) is a small, flat, rectangular stationary pointing device with a sensitive surface of 1.5-2 square inches.
- The user has to slide his or her fingertips across the surface of the pad to point to a specific object on the screen.
- The surface translates the motion and position of the user's fingers to a relative position on the screen.

**Advantages:**

- Occupies less space.
- Easy to use.
- Built in keyboard so need to carry an extra device.

**Handheld devices:**

- A handheld devices is a pocket-sized computing device with a display screen and touch input and/or a miniature keyboard.
- Some examples are:
  1. Smartphone's
  2. PDA's

**Joystick:**

- Joystick is a cursor control device widely used in computer games and CAD/CAM applications.
- It consists of a hand-held lever that pivots on one end and transmits its coordinates to a computer.
- It has one or more push-buttons, called switches, whose position can also be read by the computer.

**Stylus:**

- A stylus is a pen-shaped input device used to enter information or write on the touch screen of a phone.
- Stylus is a small stick that can also be used to draw lines on a surface as input to a computer, choose an option from a menu, move the cursor to another location on the screen, take notes and create short messages.
- The stylus usually slides into a slot built into the smart phone for that purpose.

**Touch screen:**

- A touch screen is a display screen which can identify the occurrence and position of a touch inside the display region.
- The user can touch the screen either by his finger or by using a stylus.
- These displays can be connected to computers, laptops, PDAs, cell phones etc.

**Optical devices:**

- Optical devices, also known as data-scanning devices, use light as a source of input for detecting or recognizing different objects such as characters, marks, codes, and images.
- These devices convert these objects into digital data and send it to the computer for further processing.
- Some optical devices that are discussed include barcode readers, image scanners, optical character recognition (OCR) devices, optical mark readers (OMR), and magnetic ink character recognition (MICR) devices.

**Barcode readers:**

- A barcode reader (or price scanner or point-of-sale scanner) is a hand-held input device which is used to capture and read information stored in a barcode.
- A barcode reader consists of a scanner, a decoder, and a cable used to connect the reader with a computer.
- The barcode reader merely captures and translates the barcode into numbers and/or letters.
- To make use of the information captured it must be connected to a computer for further processing.
- For this purpose, the barcode reader is connected to a computer through a serial port, keyboard port, or an interface device called a wedge.

Advantages: Cheap, Portable, Used to read data stored in bar codes, Handy and easy to use

**Image scanner:**

- It is a device that captures images, printed text, handwriting from different sources and converts it into a digital image for computer editing and display.



- Scanners come in hand-held, feed-in, and flatbed types.
- In the flat bed scanner, the object to be scanned is placed on a glass pane and a sensor and light moves along the pane, reflecting off the image placed on the glass.
- A hand image scanner has to be manually moved across an object or image to be scanned.
- The scanner produces light from green LEDs which highlight and scan the image onto a computer for further processing.
- Film scanners are usually used in photography and slides.
- The slide or negative film is first inserted in strips of six or less frames into the film scanner, and then moved across a lens and sensor to capture the image.

**Advantages:**

- Any printed or handwritten document can be scanned and stored in a computer for further processing.
- The scanned and stored document will never deteriorate in quality with time.
- The document can be displayed and printed whenever required. • There is no fear of loss of documents.
- The user can scan important documents and store them permanently in the computer.

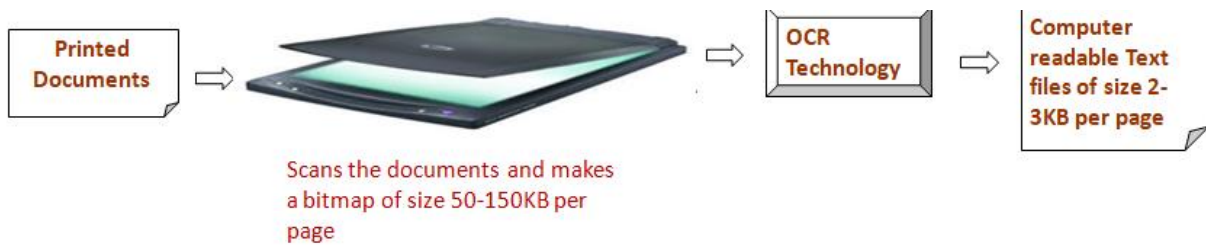
**Disadvantages**

- Scanners are usually costlier than other input devices.
- The documents that are scanned and stored as images have a higher size as compared to other equivalent text files.
- Text documents are scanned and stored as images. Therefore, they occupy more space and are also not editable because computers cannot interpret individual characters and numbers in the image.

**Optical Character Recognition (OCR):**

- OCR is the process of converting printed materials into text or word processing files that can be easily edited and stored.
- The steps involved in OCR include:
  1. Scanning of the text character-by-character

2. Analyzing the scanned-in image to translate the character image into character codes (ex ASCII)



**Advantages:**

- Printed documents can be converted into text files
- Advanced OCR can recognize handwritten text and convert them into computer readable text files

**Disadvantages:**

- OCR cannot recognize all types of fonts
- Documents that are poorly types or have strikeover cannot be recognized
- Very old documents when passed through OCR may not have an exact copy of the text file.

**OPTICAL MARK RECOGNITION**

- OMR is the process of electronically extracting data from marked fields, such as checkboxes and fill-infields, on printed forms.
- The optical mark reader is fed with an OMR sheet to detect the presence of a mark by measuring reflected light levels.
- The OM reader interprets this pattern marks and spaces and stores the interpreted data in computer for storage, analysis and reporting.
- The error rate for OMR technology is less than 1%.
- It is used for applications in which large numbers of hand-filled forms have to be quickly processed with great accuracy, such as surveys, reply cards, questionnaires, ballots or sheets for multiple choice questions.

**Advantages:**

- Optical mark readers works with a very fast speed. They can read up to 9,000 forms per hour
- They are accurate machines with error rates of just 1%

**Disadvantages:**

- Difficult to gather large amount of information.
- Some data may be missing in the scanned documents.
- It is a sensitive device that rejects the OMR sheet if it is folded, torn or crushed.

**MAGNETIC INK CHARACTER READER (MICR)**

- MICR is used to verify the legitimacy or originality of paper documents, especially checks.
- MICR consists of magnetic ink printed characters which can be recognized by high speed magnetic recognition devices .
- The printed characters provides important information (like check number, bank routing number, checking account number and in some cases the amount of the check) for processing to the receiving party.
- MICR is widely used to enhance security, speed up the
- sorting of documents and minimize the exposure to check fraud.

**Audiovisual Input devices:**

- Audio devices.
- Video Input devices

**Audio devices**

- Audio devices are used to either capture or create sound. They enable computers to accept music, speech or sound affects for recording and/or editing.
- Microphone and CD player are examples of two widely used audio input devices.
- Microphone feeds audio input to the computer. The computer must have a sound card to convert analog signals generated through microphone into digital data so that it can be stored in the computer.
- When the user wants to hear the pre-recorded audio input, the sound card converts the digital data into analog signals and sends it to the speakers.

**Advantages:** Audio devices can be used by people who have visual problems; It is best used in situations where users want to avoid i/p through keyboard or mouse

**Disadvantages:** Audio input devices are not suitable in noisy places; With audio input devices it is difficult to clearly distinguish between two similar sounding words like “sea” and “see”

### Video Input Devices

- Video input devices are used to capture video from the outside world into the computer.
- Digital camera is used to capture images or videos. It digitizes the image or video and stores them on a memory card.
- The data can then be transferred to the computer using a cable which connects computer to the digital camera.
- Web cameras also capture videos which can be transferred via internet in real time.

### Advantages:

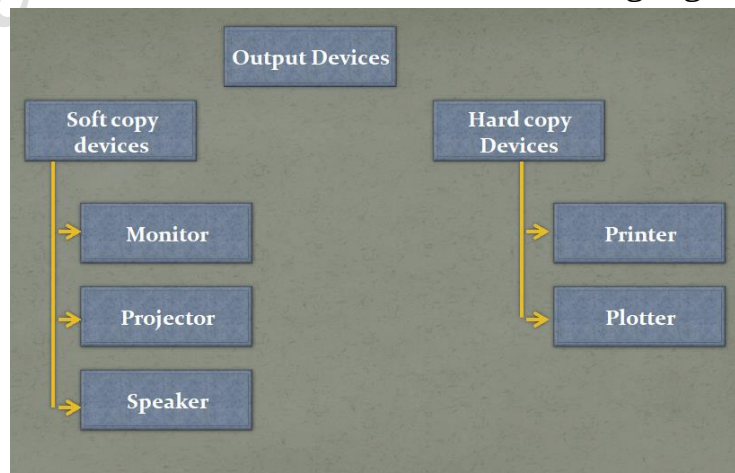
- Video input devices are very useful for applications like video conferencing
- Video input devices can be used to record memorable moments in one’s life
- Video input devices can be used to check security

### Disadvantages:

- Videos and images captured using video input devices have a very big file size and there must be compressed before being stored on the computer.

### OUTPUT DEVICES

- Any device that outputs/gives information from a computer is called an output device.
- Output devices are electromechanical devices which accept digital data from the computer and convert them into human understandable language.



## SOFT COPY DEVICES

- Soft copy output devices are those output devices which produce an electronic version of an output.
- For example, a file which is stored on hard disk, CD, pen drive, etc is displayed on the computer screen (monitor).

### Features of a soft copy output include:

- The output can be viewed only when the computer is on.
- The user can easily edit the soft copy output
- Soft copy cannot be used by people who do not have a computer
- Searching data in a soft copy is easy and fast.
- Electronic distribution of a soft copy is cheaper. It can be done easily and quickly

### Monitors:

- The monitor is a soft copy output device used to display video and graphics information generated by the computer through the video card.
- Monitors have 3 variants: Cathode Ray tube(CRT), Liquid Crystal Display(LCD), and Plasma.



**LCD**



**CRT**

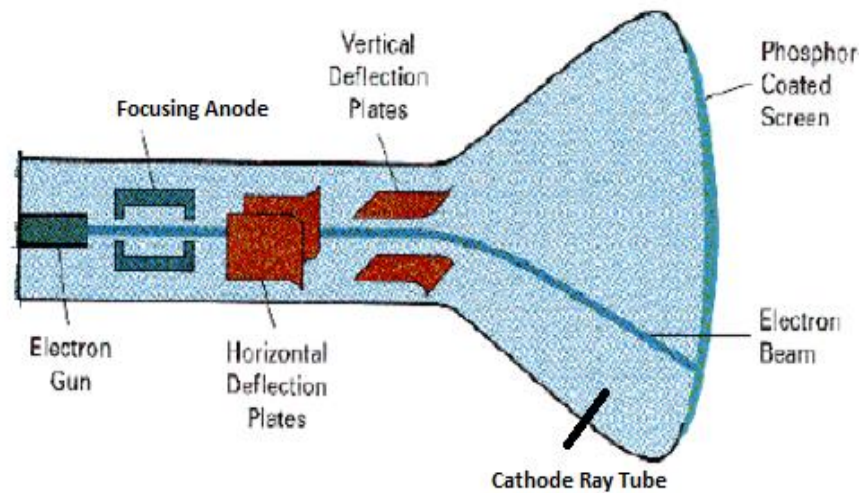


**LED**

## CATHODE RAY TUBE MONITORS

- CRT monitors work by firing charged electrons at a phosphorus film.
- When electron hit the phosphor coated screen, it glows thereby enabling the user to see the output.
- In a cathode ray tube, the "cathode" is a heated filament which is placed in a vacuum created inside a glass "tube."
- The "ray" is a stream of electrons which comes out from a heated cathode into the vacuum.
- The focusing anode focuses the stream of electrons to form a tight beam which is then accelerated by an accelerating anode.
- This tight, high-speed beam of electrons flies through the vacuum in the tube and hits the flat screen at the other end of the tube.

- This screen is coated with phosphor, which glows when struck by the beam, thereby displaying the picture which the user sees on the monitor.



### Working of CRT monitor

#### Advantages:

- It provides images of good quality.
- These are cheapest when compared to LCD and plasma monitors.
- The images are clear even when we try to view in different angle.

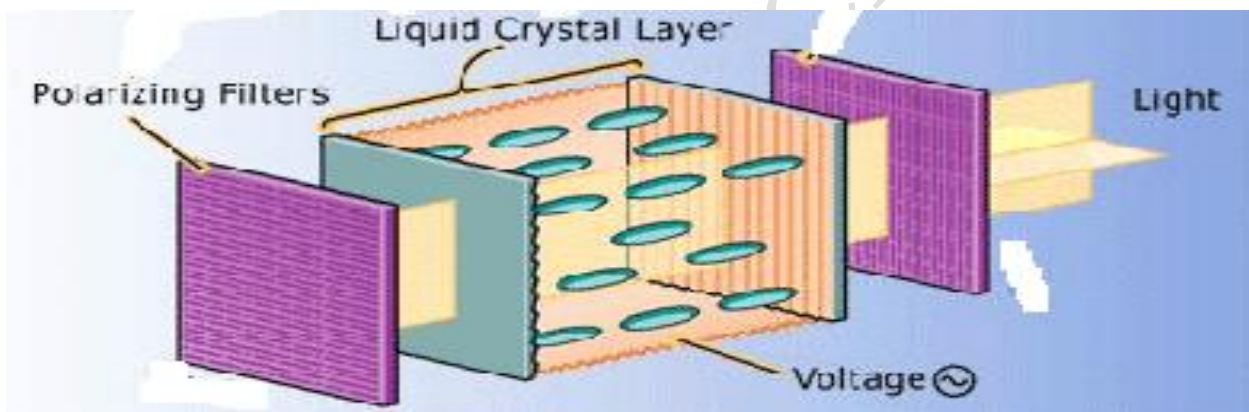
#### Disadvantages:

- They occupy a large space on the desk.
- They are bigger in size and weight and therefore difficult to move from one place to another when compared with other types of monitor.
- Power consumption is higher than the other monitors.

### LIQUID CRYSTAL DISPLAY MONITORS

- LCD monitor is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals which do not emit light directly.
- LCD screens are used in a wide range of applications ranging from computer monitors, television, instrument panels, aircraft cockpit displays, signage, to consumer devices like such as video players, gaming devices, clocks, watches, calculators, and telephones.

- Liquid crystal display technology is based on blocking light.
- The LCD consists of two pieces of polarizing filters (or substrates) that contain a liquid crystal material between them.
- A backlight creates light which is made to pass through the first substrate.
- Simultaneously, the electrical currents cause the liquid crystal molecules to align to allow varying levels of light to pass through to the second substrate and create the colors and images are seen on the screen.
- Most LCD displays use active matrix technology in which a thin film transistor(TFT) arranges tiny transistors and capacitors in a matrix of the display.
- Passive matrix technology is the other type of LCD, which uses a grid of conductive metal to charge each pixel.



**Working of LCD monitor.**

**Advantages:**

- They are very compact and light weight, consume less power.
- There is little or no flicker of images.
- They are more reliable than CRTs and can be made in almost any size or shape.

**Disadvantages:**

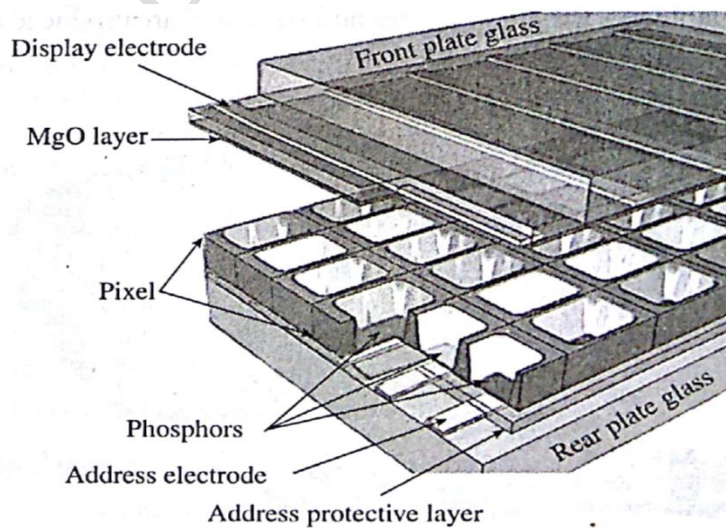
- They are more expensive than CRTs.
- Images are not very clear when tried to view from an angle.

**PLASMA MONITORS**

- Plasma monitors are thin and flat monitors widely used in TVs and computers. The plasma display contains two glass plates that have tiny cells filled with xenon and neon gas.
- The display electrode is covered by a magnesium oxide protective layer and is arranged in horizontal rows along the screen while the address electrodes are arranged in vertical columns thereby forming grid like structure.
- To ionize the gas in a particular cell, the electrodes that intersect at that cell are charged at least thousands of times in a small fraction of a second
- An electric current begins to flow through the gas in the cell.
- The current creates a rapid flow of charged particles thereby stimulating the gas atoms to release ultraviolet photons.
- When these UV photons hit a phosphor atom in the cell, one of the phosphor's electrons jumps to a higher energy level and the atom heats up. When the electron falls back to its normal level, it releases energy in the form of a visible light photon.

**Advantages:** The technology allows producing a very wide screen using extremely thin materials, very bright images are formed which look good from every angle and are not heavy and hence portable.

**Disadvantages:** Expensive, high power consumption.





## **PROJECTOR**

- A projector is a device which takes an image from a video source and projects it onto a screen or other surface.
- These days, projectors are used for a wide range of applications varying from home theater systems to organizations for projecting information and presentations onto screens large enough for rooms filled with people to see.
- LCD Projector make use of their own light to display the image on the wall and are based on LCD technology. Requires darkened room as image may be blurred.
- Digital light processing (DLP) projector use number of mirrors to reflect the light. The room may be darkened or not as it displays clear image in both the situations.

## **SPEAKERS**

- Today all business and home users demand sound capabilities and thus different types of speakers to enable users to enjoy music, movie, or a game and the voice will be spread through the entire room.
- With good quality speakers, the voice will also be audible even to people sitting in another or room or even to neighbors.
- However, in case the user wants to enjoy loud music without disturbing the people around him, he can use a headphone.
- Another device called headset was developed to allow the users to talk and listen at the same time, using the same device.

## **HARD COPY OUTPUT DEVICES**

Hard copy output devices produce a physical form of output. For example, the content of a file printed on a paper is a form of hard copy output.

### **Printers:**

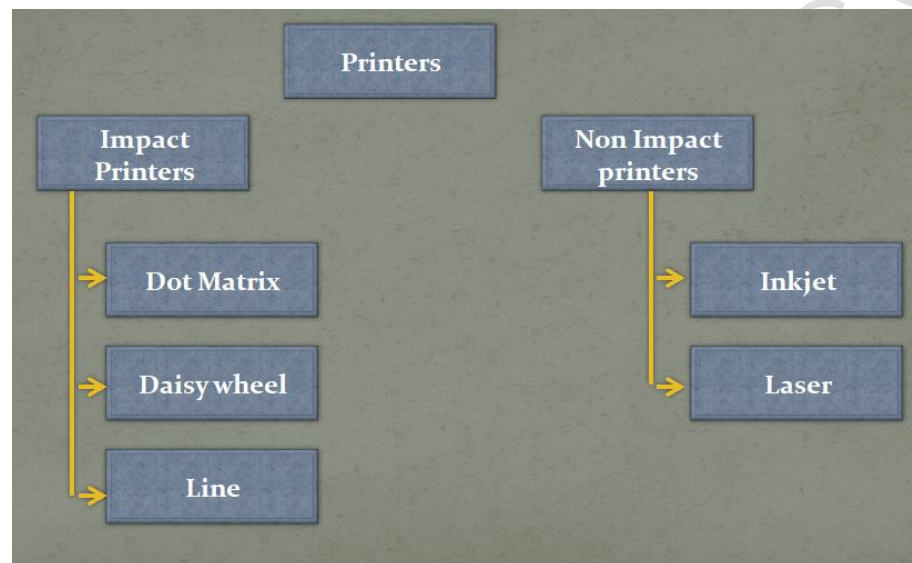
Printer is a device that outputs text and graphics information obtained from the computer and prints it on to a paper. Printers are available in the market in a variety of size, speed, sophistication, and cost. The qualities of printer which are of interest to users include:

**Color:** Colored printouts are needed for presentations or maps and other pages where color is part of the information. They are more expensive.

**Memory:** Most printers have a small amount of memory that can be expanded by the user. Having more memory makes enhances the speed of printing

**Resolution:** The resolution of a printer means the sharpness of text and images on paper. It is usually expressed in dots per inch (dpi). Even the least inexpensive printer provides sufficient resolution for most purposes at 600 dpi.

**Speed:** Speed means number of pages that are printed in one minute. While high speed printers are a little expensive, the inexpensive printers on the other hand can print only about 3 to 6 sheets per minute. Color printing is even slower.



**Impact Printer:**

- They create characters by striking an inked ribbon against the paper.
- Ex., dot-matrix printers, daisywheel printers, and most types of line printer.

**Advantages:**

- These allow the user to produce carbon copies and are cheap.

**Disadvantages:**

- Impact printers are slow.
- They offer poor printing quality and can be extremely noisy.
- They can print only using the standard format.

**DOT MATRIX PRINTER:**

- A dot matrix printer prints characters and images of all types as a pattern of dots.
- It has a print head (or hammer) that consists of pins representing the character or image.
- The print head runs back and forth, or in an up and down motion, on the page and prints by striking an ink-soaked cloth ribbon against the paper, much like the print mechanism on a typewriter.



### **Advantages:**

- It can produce carbon copies; offers lowest printing cost per page;
- Widely used for bulk printing where quality of the print is not of much importance; is cheap;
- When the ink is about to finish, the printout gradually fades rather than suddenly stopping partway through a job
- It can use continuous paper rather than individual sheets, making them useful for data logging.

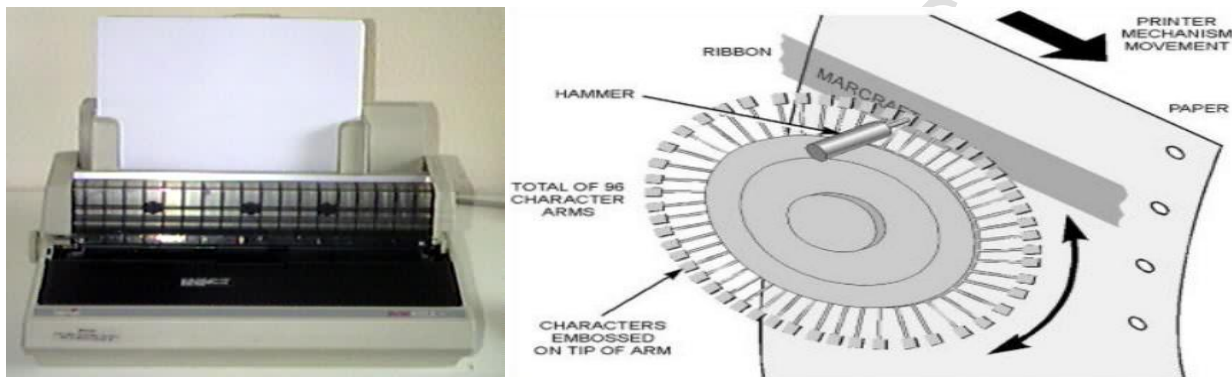
### **Disadvantages:**

- It creates a lot of noise when the pins strike the ribbon to the paper.
- It can only print lower-resolution graphics, with limited quality
- It is very slow and has poor print quality

### **DAISY WHEEL PRINTER**

- Daisy wheel printers use an impact printing technology to generate high-quality output comparable to typewriters but three times faster.

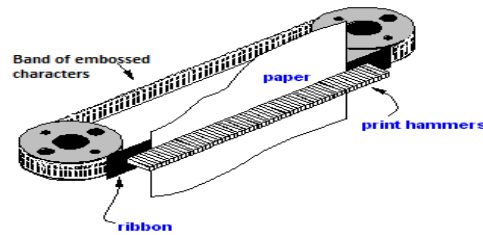
- The print head of a daisy wheel printer is a circular wheel, about 3 inches in diameter with arms or spokes. The characters are embossed at the outer end of the arms.
- To print a character, the wheel is rotated in such a way that the character to be printed is positioned just in front of the printer ribbon.
- The spoke containing the required character is then hit by a hammer thereby striking the ribbon to leave an impression on the paper placed behind the ribbon. Movement of all these parts is controlled by microprocessor in the printer.
- The key benefit of using a daisy wheel printer is that the print quality is high as the exact shape of the character hits the ribbon to leave an impression on paper.



### LINE PRINTER:

Line printer is a high speed impact printer in which one typed line is printed at a time. The speed of a line printer usually varies from 600 to 1200 lines-per-minute or approximately 10 to 20 pages per minute. They are widely used in datacenters and in industrial environments. Band printer is a commonly used variant of line printers.

**Band Printer:** A band printer (loop printer) is an impact printer . The set of characters are permanently embossed on the band and this set cannot be changed unless the band is replaced. The band itself revolves around hammers that push the paper against the ribbon, allowing the desired character to be produced on the paper. However, band printers cannot be used for any graphics printing as the characters are predetermined and cannot be changed unless the band is changed.



### **Band printer**

#### **Non Impact Printer:**

- Non-impact printers are much quieter than impact printers as their printing heads do not strike the paper.
- They offer better print quality, faster printing and the ability to create prints that contain sophisticated graphics.
- Non-impact printers use either solid or liquid cartridge-based ink which is either sprayed, dripped or electro statically drawn onto the page. The main types of non-impact printer are: inkjet, printer, laser printer and thermal printer.

#### **Advantages:**

- These produce prints of good quality and hence render sophisticated graphics.
- They are noiseless, fast and can print text in different fonts.

#### **Disadvantages:**

- They are expensive

#### **INKJET PRINTERS:**

- In inkjet printers, the print head has several tiny nozzles, also called jets.
- As the paper moves past the print head, the nozzles spray ink onto it, forming the characters and images.
- The dots are extremely small (usually between 50 and 60 microns in diameter) and are positioned very precisely, with resolutions of up to 1440x720 dots per inch (dpi).
- There is usually one black ink cartridge and one so-called color cartridge containing ink in primary pigments (cyan, magenta, and yellow).

- While inkjet printers are cheaper than laser printers, they are more expensive to maintain.
- The cartridges of inkjet printers have to be changed more frequently and the special coated paper required to produce high-quality output is very expensive.
- So the cost per page of inkjet printers becomes ten times more expensive than laser printers.
- Therefore, inkjet printers are not well-suited for high-volume print jobs.



## **LASER PRINTER**

- It is a non-impact printer that works at a very high speed and produces high quality text and graphics. It uses the photocopier technology.
- When a document is sent to the printer, the following steps takes place:
  1. A laser beam "draws" the document on a drum (which is coated with a photo-conductive material) using electrical charges.
  2. After the drum is charged, it is rolled in toner (a dry powder type of ink).
  3. The toner sticks to the charged image on the drum.
  4. The toner is transferred onto a piece of paper and fused to the paper with heat and pressure.
  5. After the document is printed, the electrical charge is removed from the drum and the excess toner is collected.
- While color laser printers are also available in the market but users prefer only monochrome printers because a color laser printer is up to 10 times more expensive than a monochrome laser printer.

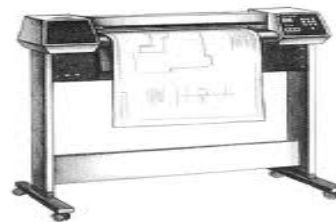


## PLOTTERS

- A plotter is used to print vector graphics with a high print quality. They are widely used to draw maps, in scientific applications and in applications like CAD, CAM and CAE
- A **drum plotter** is used to draw graphics on a paper that is wrapped around a drum. It works by rotating the drum back and forth to produce vertical motion. The pen which is mounted on a carriage is moved across the width of the paper. Hence, the vertical movement of the paper and the horizontal movement of the pen create the required design under the control of the computer.



**Drum plotter**



**Flatbed plotter**

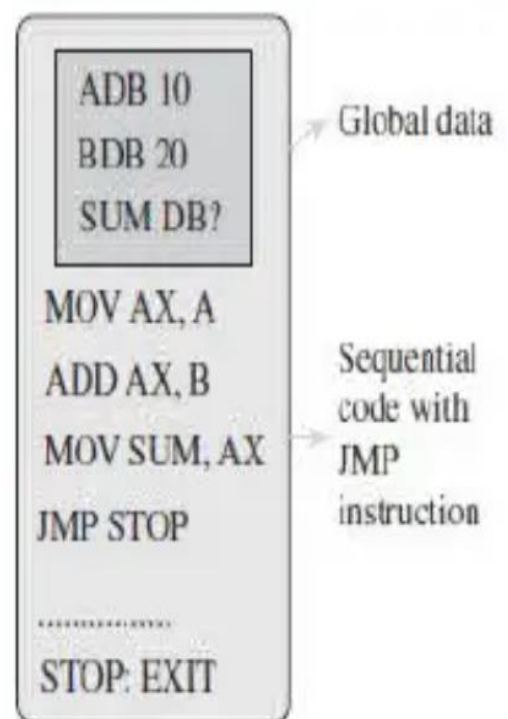
- In a **flatbed plotter**, the paper is spread on the flat rectangular surface of the plotter and the pen is moved over it. Flatbed plotters are less expensive and used in many smaller computing systems. In this type of plotter, the paper is not moved rather plotting is done by moving an arm that moves a pen over paper.

## PROGRAMMING PARADIGMS

- A programming paradigm is a fundamental style of programming that defines how the structure and basic elements of a computer program will be built.
- The style of writing programs and the set of capabilities and limitations that a particular programming language has depends on the programming paradigm it supports.
- These paradigms, in sequence of their application, can be classified as follows:
  1. Monolithic programming — emphasizes on finding a solution
  2. Procedural programming—lays stress on algorithms
  3. Structured programming—focuses on modules
  4. Object-oriented programming—emphasizes on classes and objects

### Monolithic programming:

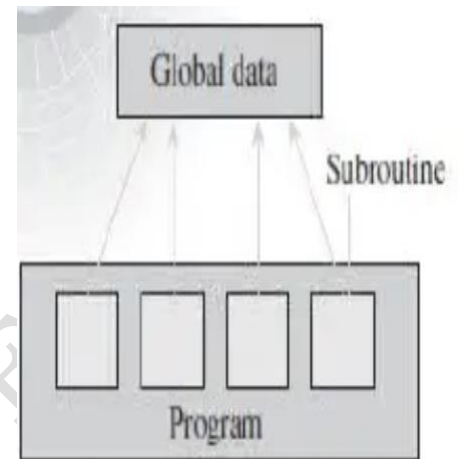
- Monolithic programs have just one program module as such programming languages do not support the concept of subroutines.
- Therefore, all the actions required to complete a particular task are embedded within the same application itself.
- This not only makes the size of the program large but also makes it difficult to debug and maintain.
- Programs written using monolithic programming languages consist of global data and sequential code.
- The global data can be accessed and modified from any part of the program. Examples are Assembly Language and BASIC.





### **Procedural programming:**

- In procedural languages, a program is divided into subroutines that can access global data.
- To avoid repetition of code, each subroutine performs a well-defined task.
- A subroutine that needs the service provided by another subroutine can call that subroutine.
- Therefore, with 'jump', 'goto', and 'call' instructions, the sequence of execution of instructions can be altered.
- FORTRAN and COBOL are two popular procedural programming languages.



### **Advantages**

- The only goal is to write correct programs
- Programs are easier to write as compared to monolithic programming

### **Disadvantages**

- No concept of reusability
- Requires more time and effort to write programs
- Programs are difficult to maintain
- Global data is shared and therefore may get altered (mistakenly)

### **Structured programming:**

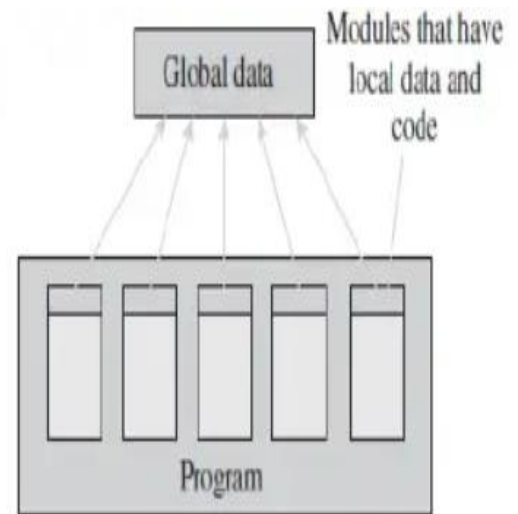
- Structured programming employs a top-down approach in which the overall program structure is broken down into separate modules.
- This allows the code to be loaded into memory more efficiently and also be reused in other programs.
- Modules are coded separately and once a module is written and tested individually, it is then integrated with other modules to form the overall program.

- Structured programming is based on modularization which groups related statements together into modules.

### Advantages

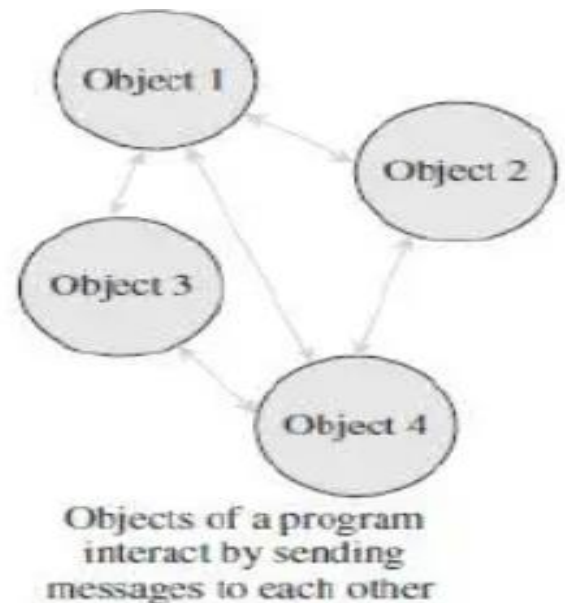
- With modules, many programmers can work on a single, large program, with each working on a different module.
- A structured program takes less time to be written than other programs.
- Modules or procedures written for one program can be reused in other programs as well.

**Disadvantages:** Not data-centered, Global data is shared and therefore may get inadvertently modified, Main focus is on functions



### Object-oriented programming (oop)

- The object-oriented paradigm is task-based and data-based. In this paradigm, all the relevant data and tasks are grouped together in entities known as objects. It treats data as a critical element in the program development and restricts its flow freely around the system.
- The striking features of OOP include the following:
  1. Programs are data centered.
  2. Programs are divided in terms of objects and not procedures.
  3. Functions that operate on data are tied together with the data.
  4. Data is hidden and not accessible by external functions.
  5. New data and functions can be easily added as and when required.
  6. Follows a bottom-up approach for problem solving.



## Design and Implementation of Efficient Programs

- The design and development of correct, efficient and maintainable programs depend on the approach adopted by the programmer to perform various activities that need to be performed during the development process.
- The entire programs and software development process is divided into a number of phases.
- This phase is the Software Development Life cycle.



### 1. Requirement analysis:

- In this phase, user expectations are gathered to know why the software/program has to be built.
- Then all the gathered requirements are analyzed to frame an objective.
- The last activity in this phase is to document all the requirements to avoid any further doubts.
- The functionality, capability, performance, and availability of hardware and software components are analyzed in this phase.

### 2. Design:

- In this phase, a plan of actions is made before the actual development process could start.
- This plan will be followed throughout the development process.
- The core structure of the software/program is broken down into modules.
- The solution of the program is then specified for each module in the form of algorithms, flowcharts, or pseudo codes.

### 3. Implementation:

- Designed algorithms are converted into program code using any of the high level languages.
- The choice of language depends on the type of program like whether it is a system or an application program.
- Program codes are tested by the programmer to ensure their correctness.

- While constructing the code, the development team checks whether the software is compatible with the available hardware and other software components that were mentioned in the Requirements Specification Document created in the first phase.

#### **4. Testing:**

- All the modules are tested together to ensure that the overall system works well as a whole product.
- Although individual pieces of codes are already tested by the programmers in the implementation phase, there is always a chance for bugs to creep in the program when the individual modules are integrated to form the overall program structure.
- Software is tested using a large number of varied inputs also known as test data to ensure that the software is working as expected by the users' requirements that were identified in the requirements analysis phase.

#### **5. Software Deployment, Training and Support:**

- After testing, the software is deployed in the production environment.
- Software Training and Support is a crucial phase which makes the end users familiar with how to use the software.
- Moreover, people are often resistant to change and avoid venturing into an unfamiliar area, so as a part of the deployment phase, it has become very crucial to have training classes for the users of the software.

#### **6. Maintenance:**

- Maintenance and enhancements are ongoing activities which are done to cope with newly discovered problems or new requirements.
- Such activities may take a long time to complete as the requirement may call for addition of new code that does not fit the original design or an extra piece of code required to fix an unforeseen problem.
- As a general rule, if the cost of the maintenance phase exceeds 25% of the prior-phases cost then it clearly indicates that the overall quality of at least one prior phase is poor.
- In such cases, it is better to re-build the software (or some modules) before maintenance cost is out of control.

#### **Algorithms**

- An algorithm provides a blueprint to writing a program to solve a particular problem.
- It is considered to be an effective procedure for solving a problem in a finite number of steps.

- A well-defined algorithm always provides an answer, and is guaranteed to terminate.
- Algorithms are mainly used to achieve software re-use.
- A good algorithm must have the following characteristics
  - Be precise
  - Be unambiguous
  - Not even a single instruction must be repeated infinitely
  - After the algorithm gets terminated, the desired result must be obtained

### Control Structures used in Algorithms

Sequence: Sequence means that each step of the algorithm is executed in the specified order.

```
Step 1: Input the first number as A
Step 2: Input the second number as B
Step 3: SET SUM = A + B
Step 4: PRINT SUM
Step 5: END
```

Decision: Decision statements are used when the outcome of the process depends on some condition. For example, if  $x=y$ , then print "EQUAL". Hence, the general form of the if construct can be given as if condition then process.

```
Step 1: Input the first number as A
Step 2: Input the second number as B
Step 3: IF A = B
        Then PRINT "EQUAL"
        ELSE
        PRINT "NOT EQUAL"
Step 4: END
```








Repetition: Repetition, which involves executing one or more steps for a number of times, can be implemented using constructs such as while, do-while, and for loops. These loops execute one or more steps until some condition is true.

```
Step 1: [INITIALIZE] SET I = 0, N = 10
Step 2: Repeat Step while I <= N
Step 3: PRINT I
Step 4: SET I + 1
Step 5: END
```

**Note: Please refer to the examples solved in lecture.**

**Flowchart:**

- Flowchart is a graphical or symbolic representation of a process.
- It is basically used to design and document virtually complex processes to help the viewers to visualize the logic of the process, so that they can gain a better understanding of the process and find flaws, bottlenecks, and other less obvious features within it.
- When designing a flowchart, each step in the process is depicted by a different symbol and is associated with a short description. The symbols in the flowchart are linked together with arrows to show the flow of logic in the process.

Symbol	Name	Represents
	Oval	Start and End
	Parallelogram	Input/Output
	Rectangle	Statements or expressions
	Rhombus	Decision making or condition checking
	Hexagon	Looping
	Circle	Connector
	Double ended Rectangle	Functions

**Note: Please refer to the examples solved in lecture.**

**Pseudocode:**

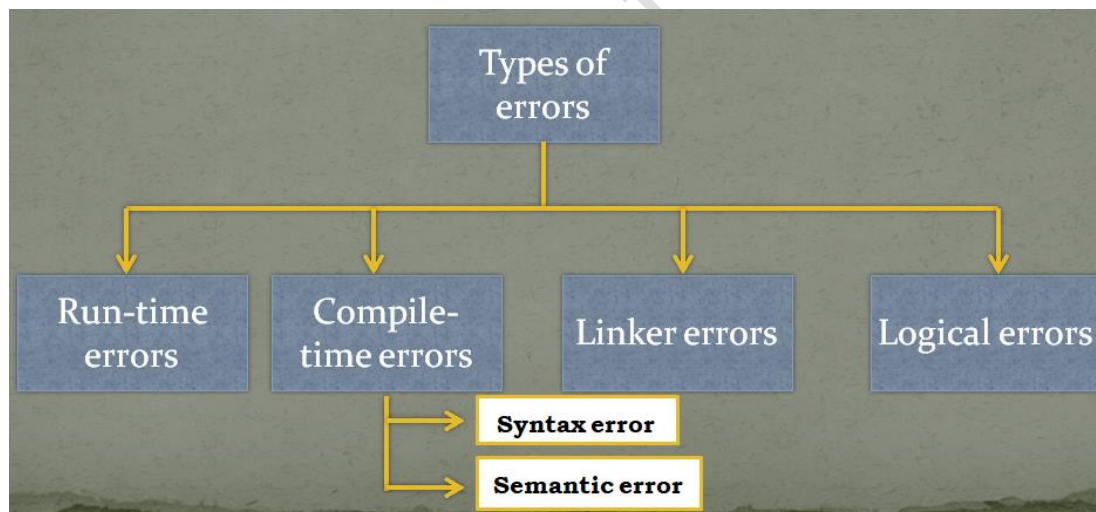
- Pseudocode is a compact and informal high-level description of an algorithm that uses the structural conventions of a programming language.

- It is basically meant for human reading rather than machine reading, so it omits the details that are not essential for humans. Such details include variable declarations, system-specific code, and sub-routines.
- Pseudocodes are an outline of a program that can be easily converted into programming statements.
- They consist of short English phrases that explain specific tasks within a program's algorithm. They should not include keywords in any specific computer language. The sole purpose of pseudocodes is to enhance human understandability of the solution.

**Note: Please refer to the examples solved in lecture.**

## TYPES OF ERRORS

- While writing programs, very often we get errors in our program.
- These errors if not removed will either give erroneous output or will not let the compiler to compile the program.



### 1. Run-time errors:

- Run-time Errors occur when the program is being run executed.
- Such errors occur when the program performs some illegal operation like
  1. Dividing a number by zero
  2. Opening a file that already exists

3. Lack of free memory space

4. Finding square or logarithm of negative numbers

- Run-time errors may terminate program execution, so the code must be written in such a way that it handles all sorts of unexpected errors rather terminating it unexpectedly.

- This ability to continue operation of a program despite of run-time errors is called robustness.

## 2. Compile time errors:

- Compile-time Errors occur at the time of compilation of the program.

- Such errors can be further classified as follows:

**Syntax Errors:** Syntax error is generated when rules of C programming language are violated. For example, if we write `int a:` then a syntax error will occur since the correct statement should be `int a;`

**Semantic Errors:** Semantic errors are those errors which may comply with rules of the programming language but are not meaningful to the compiler. For example, if we write, `a * b = c;` it does not seem correct. Rather, if written like `c=a*b` would have been more meaningful.

## 3. Logical errors:

- Logical Errors are errors in the program code that result in unexpected and undesirable output which is obviously not correct.

- Such errors are not detected by the compiler, and programmers must check their code line by line or use a debugger to locate and rectify the errors.

- Logical errors occur due to incorrect statements. For example, if you meant to perform `c= a + b;` and by mistake you typed `c = a * b;` then though this statement is syntactically correct it is logically wrong.

## 4. Linker errors:

- Linker Errors occur when the linker is not able to find the function definition for a given prototype.

- For example, if you write `clrscr();` but do not include `conio.h` then a linker error will be shown.



### Testing Approaches

- Testing is an activity that is performed to verify correct behavior of a program.
- It is specifically carried out with an intent to find errors.
- Unit testing is applied only on a single unit or module to ensure whether it exhibits the expected behavior.
- Integration Tests are a logical extension of unit tests. In this test, two units that have already been tested are combined into a component and the interface between them is tested. This process is repeated until all the modules are tested together. The main focus of integration testing is to identify errors that occur when the units are combined.
- System testing checks the entire system. For example, if our program code consists of three modules then each of the module is tested individually using unit tests and then system test is applied to test this entire system as one system.

### Debugging Approaches

- Debugging is an activity that includes execution testing and code correction.
- It is done to locate errors in the program code.
- Once located, errors are then isolated and fixed to produce an error-free code.
- Different approaches applied for debugging a code includes:

**Brute-Force Method:** In this technique, a printout of CPU registers and relevant memory locations is taken, studied, and documented.

It is the least efficient way of debugging a program and is generally done when all the other methods fail.

**Backtracking Method** works by locating the first symptom of error and then trace backward across the entire source code until the real cause of error is detected.

However, the main drawback of this approach is that with increase in number of source code lines, the possible backward paths become too large to manage.

Because Elimination lists all possible causes of an error is developed.

Then relevant tests are carried out to eliminate each of them.

If some tests indicate that a particular cause maybe responsible for an error then the data are refined to isolate the error.

### **Introduction to C**

- C was developed in the early 1970s by Dennis Ritchie at Bell Laboratories.
- C was initially developed for writing system software
- Today, C has become a popular language and various software programs are written using this language.
- Many other commonly used programming languages such as C++ and Java are also based on C.

### **Characteristics of C**

- C is a high level programming language which enables the programmer to concentrate on the problem and not to worry about the machine code
- Small size: C has only 32 keywords. This makes it relatively easy to learn
- C makes extensive use of function calls
- C is well suited for structured programming. In this programming approach, where it allows the user to think a problem in terms of modules where collection of all these modules make up a complete program.
- Unlike PASCAL it supports loose typing (as a character can be treated as an integer and vice versa)
- Stable language.
- Quick language: Since C programs make use of operators and data types, they are fast and efficient.
- Facilitates low level (bitwise) programming
- Supports pointers to refer computer memory, array, structures and functions.
- C is a core language as many other programming languages are based on C
- C is a portable language which means C program written on one computer can run on another computer with little or no modification.

- C is an extensible language as it enables the user to add his own functions to the C library.

### Uses of C

- C language is primarily used for system programming. The portability, efficiency, the ability to access specific hardware addresses and low runtime demand on system resources makes it a good choice for implementing operating systems and embedded system applications.
- C has been so widely accepted by professionals that compilers, libraries, and interpreters of other programming languages are often implemented in C.
- For portability and convenience reasons, C is sometimes used as an intermediate language by implementations of other languages. Example of compilers which use C this way are BitC, Gambit, the Glasgow Haskell Compiler, Squeak, and Vala.
- C is widely used to implement end-user applications

### Structure of a C program

- A C program contains one or more functions
- The statements in a C program are written in a logical sequence to perform a specific task.
- Execution of a C program begins at the main() function
- You can choose any name for the functions.
- Every program must contain one function that has its name as main().

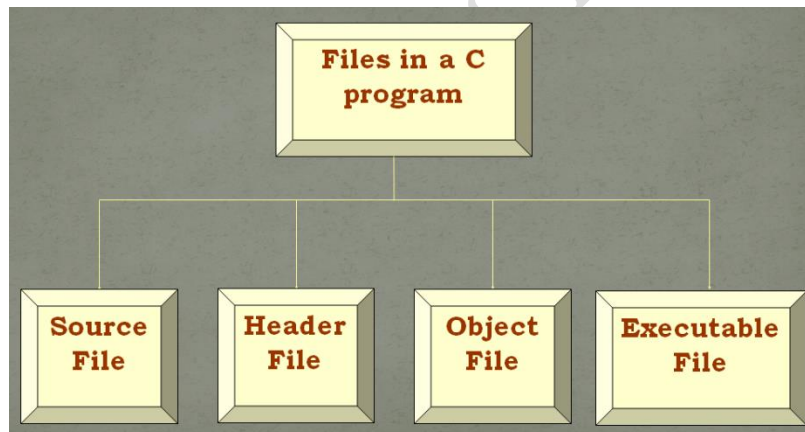


Where, #include refers to the preprocessor statement used for the standard input/output functions and it starts with the hash (#) symbol.

main() :- Refers to the function from where the execution of the program begins.

Escape sequence	Purpose	Escape sequence	Purpose
\a	Audible or visible alert	\?	Question mark
\b	Backspace: move cursor one place backward	\\	Back slash
\t	Tab	\'	Single quote
\n	Newline	\"	Double quote
\v	Vertical tab	\0	Octal constant
\f	to move the cursor to the start of the next logical page.	\x	Hexadecimal constant
\r	Carriage return moves the cursor to the start of the current line.		

### Files used in C program



### Source code file

- A source code is a list of commands that has to be assembled or compiled into an executable computer program.
- The source code file contains the source code of the program. The file extension of any C source code file is “.c”.
- This file contains C source code that defines the *main* function and maybe other functions.

- The main() is the starting point of execution when you successfully compile and run the program.
- A C program in general may include even other source code files (with the file extension .c).

### **Header file**

- When working with large projects, it is often desirable to make sub-routines and store them in a different file known as header file. The advantage of header files can be realized when
  - a) The programmer wants to use the same subroutines in different programs.
  - b) The programmer wants to change, or add, subroutines, and have those changes be reflected in all other programs.
- Conventionally, header files names ends with a “.h” extension and its name can use only letters, digits, dashes, and underscores.
- While some standard header files are available in C, but the programmer may also create his own user defined header files

### **Standard Header file**

Examples of standard header files are:

1. string.h: for string handling functions.
2. stdlib.h: for some miscellaneous functions.
3. stdio.h: for standardized input and output functions.
4. math.h: for mathematical functions
5. alloc.h: for dynamic memory allocation.
6. conio.h: for clearing the screen

### **Object Files:**

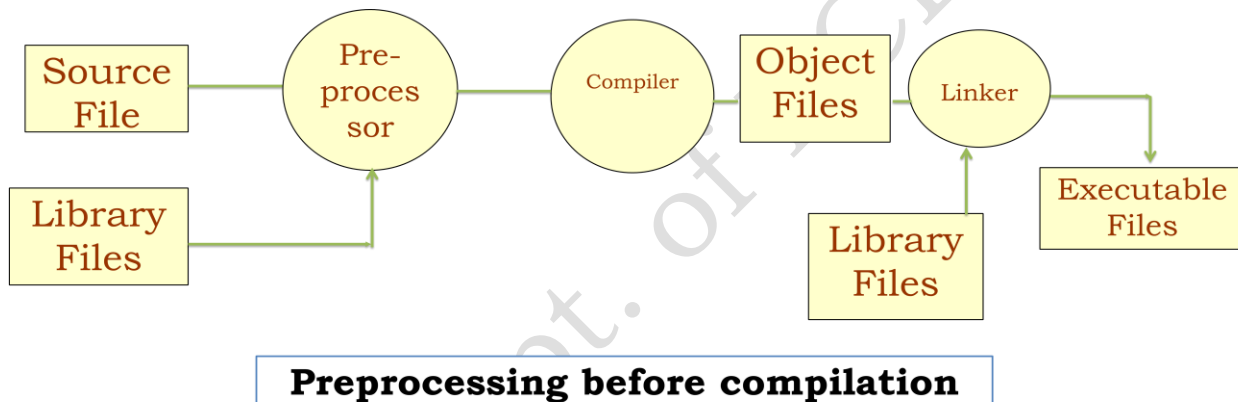
- Object files are generated by the compiler as a result of processing the source code file.
- Object files contain compact binary code of the function definitions.

- Linker uses this object file to produce an executable file (.exe file) by combining the of object files together.
- Object files have a “.o” extension, although some operating systems including Windows and MS-DOS have a “.obj” extension for the object file.

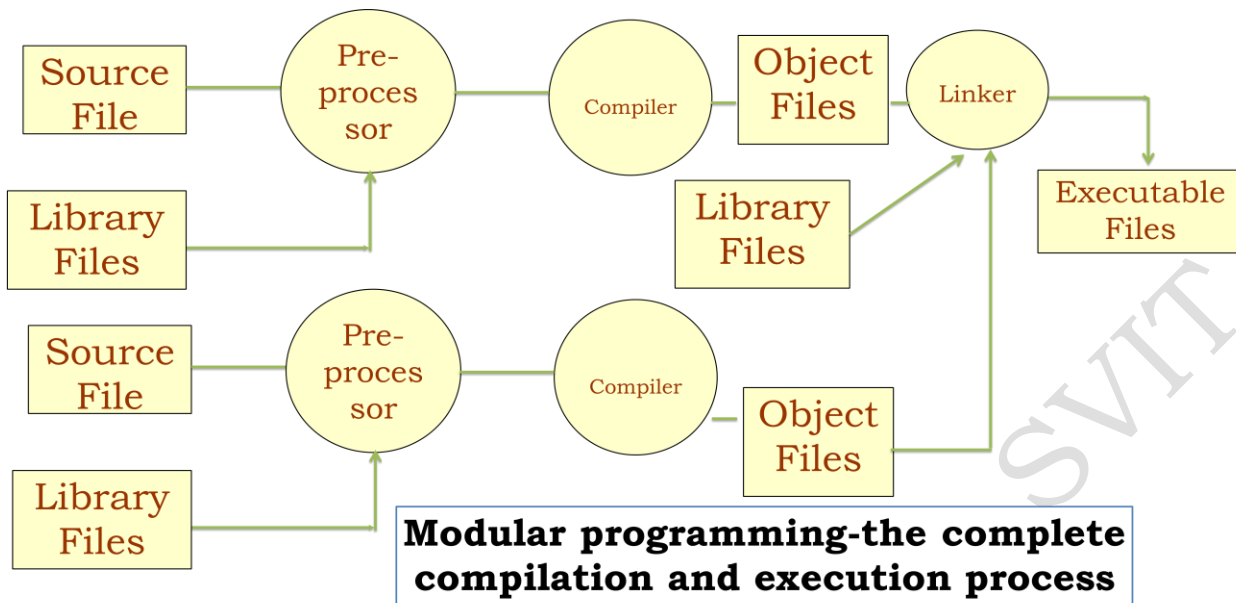
### Binary Executable File

- The binary executable file is generated by the linker.
- The linker links the various object files to produce a binary file that can be directly executed.
- On Windows operating system, the executable files have “.exe” extension.

### COMPILING AND EXECUTING C PROGRAMS



- The compiler translates the source code into an object code.
- The object code contains the machine instructions for the CPU, and calls to the operating system API(Application Programming Interface).
- However, even the object file is not a executable file.
- Therefore, in next step, the object file is processed with another special program called a linker.
- While there is a different compiler for every individual language, the same linker is used for object files regardless of the original language in which the new program was written.
- The output of the linker is an executable or runnable file.



### Using Comments

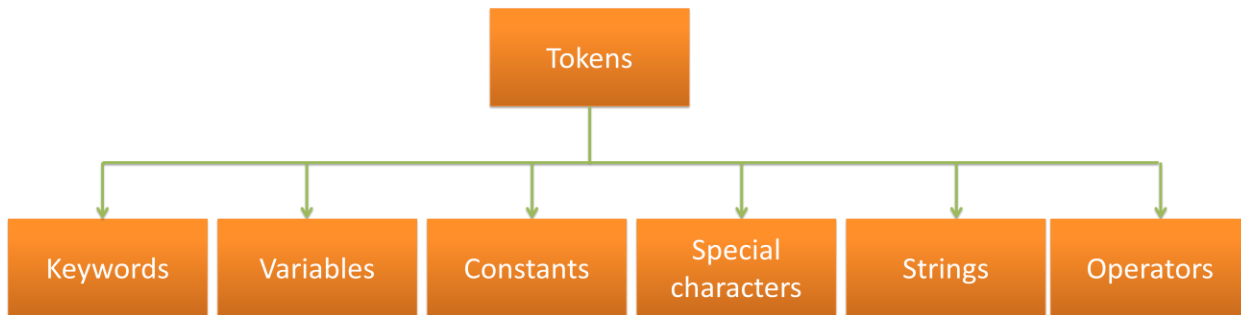
- It is a good programming practice to place some comments in the code to help the reader understand the code clearly.
- Comments are just a way of explaining what a program does. It is merely an internal program documentation.
- The compiler ignores the comments when forming the object file. This means that the comments are non-executable statements.

C supports two types of commenting.

- `//` is used to comment a single statement. This is known as a line comment. A line comment can be placed anywhere on the line and it does not require to be specifically ended as the end of the line automatically ends the line.
- `/*` is used to comment multiple statements. A `/*` is ended with `*/` and all statements that lie within these characters are commented.

### C tokens

- Tokens are the basic building blocks in C language.
- It is the smallest individual unit in C program.
- A program is constructed using a combination of these tokens. 6 main types of tokens in C are:



### Character set in C

- In C, character means any letter from English alphabet, a digit or a special symbol used to represent information.
- The character set of C can therefore be given as:
  1. English alphabet: Include both lower case (a-z) as well upper case(A-Z) letters.
  2. Digits: Include numerical digits from 0 to 9.
  3. Special characters: Include symbols such as ~, @, %, ^, &, \*, {, }, <, >, =, \_, +, -, \$, /, (, ), \, ;, :, [, ], ', ", ?, ., !, |.
  4. White space characters: These characters are used to print a blank space on the screen like \b, \t, \v, \r, \f, \n.
  5. Escape sequences.

### Keywords

- C has a set of 32 reserved words often known as keywords.
- All keywords are basically a sequence of characters that have a fixed meaning.
- By convention all keywords must be written in lowercase (small) letters.
- The keywords are for, while, do-while, auto break, case, char, continue, do, double, else, enum, extern, float, goto, if, int, long, register, return, short, signed, sizeof, static, struct, switch, typedef, union, unsigned, void, volatile



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

### Keywords in C

#### Identifiers

- Identifiers are names given to program elements such as variables, arrays and functions.

Rules for forming identifier name

- It cannot include any special characters or punctuation marks (like #, \$, ^, ?, ., etc) except the underscore "\_".
- There cannot be two successive underscores
- Keywords cannot be used as identifiers
- The names are case sensitive. So, example, "FIRST" is different from "first" and "First".
- It must begin with an alphabet or an underscore.

It can be of any reasonable length. Though it should not contain more than 31 characters.

Example: roll\_number, marks, name, emp\_number, basic\_pay, HRA, DA, dept\_code, a , sum, temp.

**Basic data types in C**

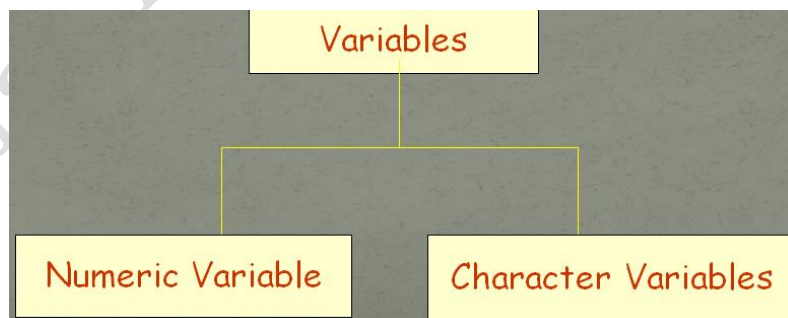
Data type	DATA TYPE	SIZE IN BYTES	RANGE	Use
Character	char	1	-128 to 127	To store characters
Integer	int	2	-32768 to 32767	To store integer numbers
Floating point	float	4	3.4E-38 to 3.4E+38	To store floating point numbers
Double	double	8	1.7E-308 to 1.7E+308	To store big floating point numbers
Valueless	void	10	3.4E-4932 to 1.1E+4932	-

DATA TYPE	SIZE IN BYTES	RANGE
char	1	-128 to 127
unsigned char	1	0 to 255
signed char	1	-128 to 127
int	2	-32768 to 32767
unsigned int	2	0 to 65535
signed short int	2	-32768 to 32767
signed int	2	-32768 to 32767

<b>short int</b>	<b>2</b>	<b>-32768 to 32767</b>
<b>unsigned short int</b>	<b>2</b>	<b>0 to 65535</b>
<b>long int</b>	<b>4</b>	<b>-2147483648 to 2147483647</b>
<b>unsigned long int</b>	<b>4</b>	<b>0 to 4294967295</b>
<b>signed long int</b>	<b>4</b>	<b>-2147483648 to 2147483647</b>
<b>float</b>	<b>4</b>	<b>3.4E-38 to 3.4E+38</b>
<b>double</b>	<b>8</b>	<b>1.7E-308 to 1.7E+308</b>
<b>long double</b>	<b>10</b>	<b>3.4E-4932 to 1.1E+4932</b>

## Variables

- A variable is defined as a meaningful name given to the data storage location in computer memory.
- When using a variable, we actually refer to address of the memory where the data is stored. C language supports two basic kinds of variables.



- Numeric variables can be used to store either integer values or floating point values.
- While an integer value is a whole numbers without a fraction part or decimal point, a floating point number, can have a decimal point in them.

- Numeric values may also be associated with modifiers like short, long, signed and unsigned.
- By default, C automatically a numeric variable signed..
- Character variables can include any letter from the alphabet or from the ASCII chart and numbers 0 – 9 that are put between single quotes.

### **Declaring Variables**

- To declare a variable specify data type of the variable followed by its name.
- Variable names should always be meaningful and must reflect the purpose of their usage in the program.
- Variable declaration always ends with a semicolon. Example,

```
int emp_num;
```

```
float salary;
```

```
char grade;
```

```
double balance_amount;
```

```
unsigned short int acc_no;
```

### **Initializing Variables**

- Assigning a value to a variable is called variable initialization.
- The syntax is `variable_name=value;` Initialization can be done in two ways:-
  1. We can assign an initial value to a variable within the declaration part itself called static initialization.

```
Ex:- int a=10;, float x=100.0000;
```

2. We can assign an initial value to a variable during the program execution called dynamic initialization.

```
Ex:- printf(Enter a value to a");
```

```
scanf("%d", &a);
```

## Constants

- Constants are identifiers whose value does not change.
- Constants are used to define fixed values like PI or the charge on an electron so that their value does not get changed in the program even by mistake.
- There are mainly four types of constants in C:

1. Integer constants

2. Floating-point constants

3. Character constants

4. String constants

To declare a constant, precede the normal variable declaration with const keyword and assign it a value. For example,

- `const float pi = 3.14;`

Another way to designate a constant is to use the pre-processor command define.

- `#define PI 3.14159`
- **The integer constants:** represents a whole number.

Ex:- 10, -200, -3456.

**2. The floating-point constants:**-represents a number that has a decimal point.

Ex:- - 250.01, 67.73234.

**3. The character constants:** represents a single character enclosed within a pair of single quotes.

Ex.:- 's', '%', '7'.

**4. The string constants:**-represents a sequence of characters enclosed within a pair of double quotes.

Ex:- "Hello", "z".

## Declaring Constants

Rules that need to be applied to a #define statement which defines a constant.

**Rule 1:** Constant names are usually written in capital letters to visually distinguish them from other variable names which are normally written in lower case characters. Note that this is just a convention and not a rule.

**Rule 2:** No blank spaces are permitted in between the # symbol and define keyword

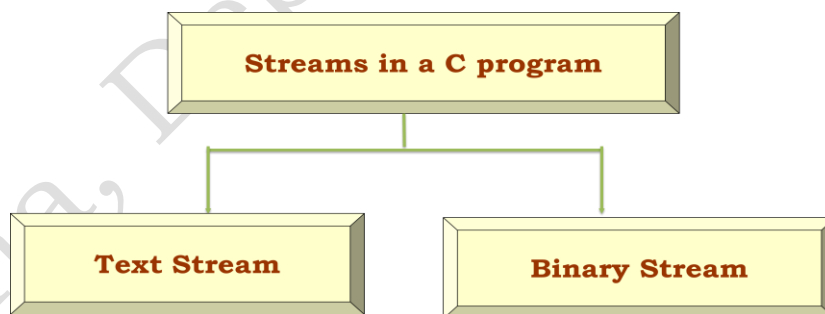
**Rule 3:** Blank space must be used between #define and constant name and between constant name and constant value

**Rule 4:** #define is a pre-processor compiler directive and not a statement. Therefore, it does not end with a semi-colon.

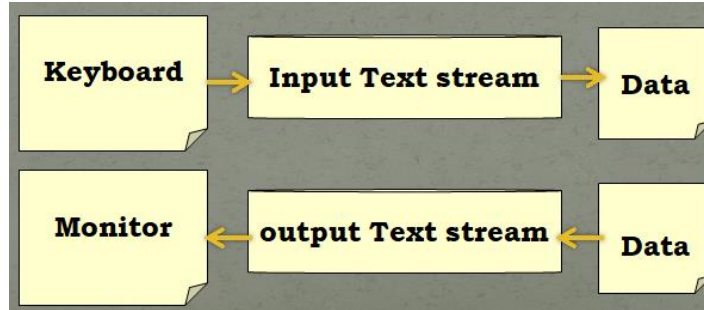
## Input/Output statements in C

### Streams:

- A stream acts in two ways. It is the source of data as well as the destination of data.
- C programs input data and output data from a stream.
- Streams are associated with a physical device such as the monitor or with a file stored on the secondary memory.



- In a text stream, sequence of characters is divided into lines with each line being terminated with a new-line character (\n). On the other hand, a binary stream contains data values using their memory representation.
- Although, we can do input/output from the keyboard/monitor or from any file but here we will assume that the source of data is the keyboard and destination of the data is the monitor.



**Formatting Input/output:**

- C supports two formatting functions.
- printf is used to convert data stored in the program into a text stream for output to monitor.
- scanf is used to convert the text stream coming from the keyboard to data values and store them in program variables.

**printf():**

- The printf() function is used to display information required to the user and also prints the values and variables.
- The syntax can be given as printf(“Control string”, variable list);
- The prototype of the control string is given by

**%[flags][width][.precision][modifier]type**

**Flags** are an optional argument which specifies output justification such as numerical sign, trailing zeros or octal, decimal, or hexadecimal prefixes.

<i>flag</i>	<i>description</i>
-	Left-justify within the data given field width
+	Displays the data with its numeric sign (either + or -)
#	Used to provide additional <u>specifiers</u> like <b>o, x, X, O, ox or oX for octal and hexa decimal values respectively for values different than zero.</b>
o	The number is left-padded with zeroes ( <b>o</b> ) <b>instead of spaces</b>

**Width** is an optional argument which specifies minimum number of positions in the output.

**Precision** is an optional argument which specifies the maximum number of characters to print.

<i>length</i>	Description
h	When the argument is a <b>short int</b> or <b>unsigned short int</b> .
l	When the argument is a <b>long int</b> or <b>unsigned long int</b> for integer specifiers.
L	When the argument is a <b>long double</b> (used for floating point specifiers)

specifier	Qualifying Input
c	For single character
d	For decimal values
F	For floating point numbers
E, e	Floating point numbers in exponential format
G, G	Floating point numbers in the shorter of e format
o	For Octal number.
s	For a sequence of (string of) characters
u	For Unsigned decimal value
x,X	For Hexadecimal value.

**Example:**

%6.3f means print floating point value of max 6 digits where 3 digits are allotted for the digits after the decimal point.

```
printf("\n Result: %6.3f", 123.53435);
```

output: Result: 123.534

**Some examples of printf:**

- `printf("\n Result: %d%c%f", 12, 'a', 2.3);`

**Output:** Result: 12a2.300000

- `printf("\n Result: %d%c%3.1f", 12, 'a', 2.3);`

**Output:** Result: 12a2.3

- `printf("\n Result: %d %c %f", 12, 'a', 2.3);`

**Output:** Result: 12 a 2.300000

- `printf("\n Result: %5d %x %#x", 232, 232, 232);`

**Output:** Result: 232 e8 0xe8



- `printf("\n Result: %5d %X %#X",232,232,232);`

**Output:** Result: 232 E8 0XE8

- `printf("the number is \n%d\n%2d\n%3d",1,1,1);`

**Output:**

the number is

1

1

1

- `printf("the number is %09.2f",123.456);`

**Output:** the number is 000123.46

- `printf("\n%7.4f\n%7.2f\n%-7.2f\n%f\n%10.2e\n%11.4e\n%-10.2e\n%e",98.7654, 98.7654, 98.7654, 98.7654, 98.7654, 98.7654, 98.7654, 98.7654, 98.7654);`

**Output:**

98.7654

98.77

98.77

98.765400

9.88e+01

9.8765e+01

9.88e+01

9.876540e+01

**scanf():**

- The `scanf()` function is used to read formatted data from the keyboard.

- The syntax is `scanf("control string",arg1,arg2,arg3);`
- The prototype of control string is

**`%[*][width][modifier]type`**

**Rules to use scanf():**

- Rule 1: Rule 1: The scan function works until:
  - (a) the maximum number of characters has been processed
  - (b) a white space character is encountered, or
  - (c) an error is detected.
- Rule 2: Every variable that has to be processed must have a conversion specification associated with it. Therefore, the following scan statement will generate an error as num3 has no conversion specification associated with it.  
`scanf("%d %d", &num1, &num2, &num3) ;`
- Rule 3: There must be a variable address for each conversion specification. Therefore, the following scanf statement will generate an error as no variable address is given for the third conversion specification.  
`scanf(*%d %d %d", &numa, &num2) ;`  
Remember that the ampersand operator (&) before each variable name specifies the address of that variable name.
- Rule 4: An error will be generated if the format string is ended with a white space character.
- Rule 5: The data entered by the user must match the character specified in the control string (except white space or a conversion specification), otherwise an error will be generated and scan will stop its processing.  
For example, consider the following scan statement.  
`scanf("%d / %d", &num1, &num2) ;` Here, the slash in the control string is neither a white space character nor a part of conversion specification, so the users must enter data of the form 21/46.
- Rule 6: Input data values must be separated by spaces.
- Rule 7: Any unread data value will be considered as a part of the data input in the next call to scanf.
- Rule 8: When the field width specifier is used, it should be large enough to contain the input data size.

**\*\*\*\*\*End\*\*\*\*\***