ELEMENTS OF COMPUTER SCIENCE AND ENGINEERING

Syllabus

UNIT – I

Basics of a Computer – Hardware, Software, Generations of computers. Hardware - functional units, Components of CPU, Memory – hierarchy, types of memory, Input and output devices. Software – systems software, application software.

UNIT – II

Software development – waterfall model, Agile, Types of computer languages – Programming, markup, scripting Program Development – steps in program development, flowcharts, algorithms, data structures – definition, types of data structures

UNIT – III

Operating systems: Functions of operating systems, types of operating systems, Device & Resource management.

Database Management Systems: Data models, RDBMS, SQL, Database Transactions, data centers, cloud services.

UNIT – IV

Computer Networks: Advantages of computer networks, LAN, WAN, MAN, internet, WiFi, sensor networks, vehicular networks, 5G communication. World Wide Web – Basics, role of HTML, CSS, XML, Tools for web designing, Social media, Online social networks.
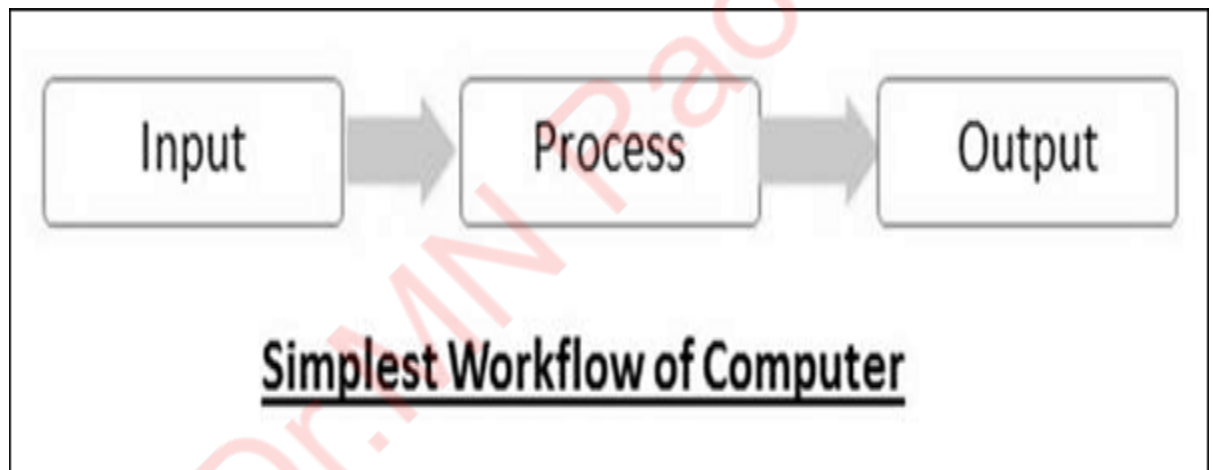
UNIT – V

Autonomous Systems: IoT, Robotics, Drones, Artificial Intelligence – Learning, Game Development, natural language processing, image and video processing.

Basics of a computer

- Computer is an electronic device that receives input, stores or processes the input as per user instructions and provides output in desired format.

Simplest Workflow of Computer

- Computer input is called data and the output obtained after processing it, based on the user's instructions is called information.

Advantages of Computers:

- **High Speed**
    - Computers are very fast devices.
    - It is capable of performing calculations of very large amounts of data.
    - It can perform millions of calculations in a few seconds as compared to man who will spend many months performing the same task.
- **Accuracy**
    - In addition to being very fast, computers are very accurate.

- The calculations are 100% error free.
- Computers perform all jobs with 100% accuracy provided that the input is correct.
- **Storage Capability**
    - Memory is a very important characteristic of computers.
    - A computer has much more storage capacity than human beings.
    - It can store large amounts of data.
    - It can store any type of data such as images, videos, text, audio, etc.
- **Automation**
    - Computer is an automatic machine.
    - Automation is the ability to perform a given task automatically. Once the computer receives a program i.e., the program is stored in the computer memory, then the program and instruction can control the program execution without human interaction.
- **Versatility**
    - A computer is a very versatile machine.
    - A computer is very flexible in performing multiple jobs.
    - At one instance, it may be solving a complex scientific problem and the very next moment it may be playing a card game.
- **Reliability**
    - A computer is a reliable machine.
    - Modern electronic components have long lives.
    - Computers are designed to make maintenance easy.
- **Reduction in Paperwork and Cost**
    - The use of computers for data processing in an organization leads to reduction in paperwork and results in speeding up the process.
    - As data in electronic files can be retrieved as and when

required, the problem of maintenance of large numbers of paper files gets reduced.

Computer - Applications:
- Business: Budgeting, Sales analysis, Financial forecasting, Managing employee database, Maintenance of stocks, etc.
- Banking: Online accounting facilities, ATM machines.
- Insurance: maintaining a database of all clients, providing online facilities.
- Education: Computer Based Education, online classes.
- Marketing: Advertising, Home Shopping.
- Healthcare: Lab-diagnostic System, Patient Monitoring System, Pharma Information System, Surgery.
- Engineering Design:
  - Structural Engineering -design of ships, buildings, budgets, airplanes, etc.
  - Industrial Engineering -design, implementation of materials, and equipment.
  - Architectural Engineering -planning towns, designing buildings using both 2D and 3D drawings.
- Military: Missile Control, Military Communication, Military Operation and Planning, Smart Weapons
- Communication: E-mail, Chatting, FTP, Telnet, Video-conferencing
- Government: Budgets, Sales tax department, Income tax department, Computation of male/female ratio, Computerization of voters lists, Computerization of PAN card, Weather forecasting

Generations of Computer

There are five computer generations
- First Generation

  The period of the first generation: 1946-1959. Vacuum tube based.
- Second Generation

The period of the second generation: 1959-1965. Transistor based.

- Third Generation

  The period of the third generation: 1965-1971. Integrated Circuit based.

- Fourth Generation

  The period of the fourth generation: 1971-1980. VLSI microprocessor based.

- Fifth Generation

  The period of fifth generation: 1980-onwards. ULSI microprocessor based.

First Generation:

- The computers of the first generation used vacuum tubes as the basic components for memory and circuitry for CPU (Central Processing Unit).

- These tubes, like electric bulbs, produced a lot of heat and the installations used to fuse frequently. Therefore, they were very expensive and only large organizations were able to afford it.

- In this generation, mainly the batch processing operating system was used. Punch cards, paper tape, and magnetic tape were used as input and output devices. The computers in this generation used machine code as the programming language.

The main features of the first generation are -

- Vacuum tube technology
- Unreliable
- Supported machine language only
- Very costly
- Generated a lot of heat
- Slow input and output devices
- Huge size
- Need of AC
- Non-portable
- Consumed a lot of electricity

Some computers of this generation were -

- ENIAC
- EDVAC
- UNIVAC
- IBM-701
- IBM-650

Second Generation

- In this generation, transistors were used that were cheaper, consumed less power, more compact in size, more reliable and faster than the first generation machines made of vacuum tubes.
- In this generation, magnetic cores were used as the primary memory and magnetic tape and magnetic disks as secondary storage devices.
- In this generation, assembly language and high-level programming languages like FORTRAN, COBOL were used. The computers used batch processing and multiprogramming operating systems.

The main features of second generation are -

- Use of transistors
- Reliable in comparison to first generation computers
- Smaller size as compared to first generation computers
- Generated less heat as compared to first generation computers
- Consumed less electricity as compared to first generation computers
- Faster than first generation computers
- Still very costly
- AC required
- Supported machine and assembly languages

Some computers of this generation were -

- IBM 1620
- IBM 7094
- CDC 1604
- CDC 3600
- UNIVAC 1108

Third Generation

- The computers of the third generation used Integrated Circuits (ICs) in place of transistors. A single IC has many transistors, resistors, and capacitors along with the associated circuitry.

- The IC was invented by Jack Kilby. This development made computers smaller in size, reliable, and efficient. In this generation remote processing, time-sharing, and multiprogramming operating systems were used.
- High-level languages (FORTRAN-II TO IV, COBOL, PASCAL PL/1, BASIC, ALGOL-68 etc.) were used during this generation.

The main features of third generation are -
- IC used
- More reliable in comparison to previous two generations
- Smaller size
- Generated less heat
- Faster
- Lesser maintenance
- Costly
- AC required
- Consumed lesser electricity
- Supported high-level language

Some computers of this generation were -
- IBM-360 series
- Honeywell-6000 series
- PDP (Personal Data Processor)
- IBM-370/168
- TDC-316

Fourth Generation:

- Computers of the fourth generation used Very Large Scale Integrated (VLSI) circuits. VLSI circuits having about 5000 transistors and other circuit elements with their associated circuits on a single chip made it possible to have microcomputers of fourth generation.
- Fourth generation computers became more powerful, compact, reliable, and affordable. As a result, it gave rise to the Personal Computer (PC) revolution.
- In this generation, time sharing, real time networks, and distributed operating systems were used. All the high-level languages like C, C++, DBASE etc., were used in this generation.

The main features of fourth generation are –
- VLSI technology used
- Very cheap
- Portable and reliable
- Use of PCs
- Very small size
- Pipeline processing
- No AC required
- Concept of internet was introduced
- Great developments in the fields of networks
- Computers became easily available

Some computers of this generation were -

- DEC 10
- STAR 1000
- PDP 11
- CRAY-1(Supercomputer)
- CRAY-X-MP(Supercomputer)

Fifth Generation

- In the fifth generation, VLSI technology became ULSI (Ultra Large Scale Integration) technology, resulting in the production of microprocessor chips having ten million electronic components.
- This generation is based on parallel processing hardware and AI (Artificial Intelligence) software. AI is an emerging branch in computer science, which interprets the means and method of making computers think like human beings.
- All the high-level languages like C and C++, Java, .Net etc., are used in this generation.
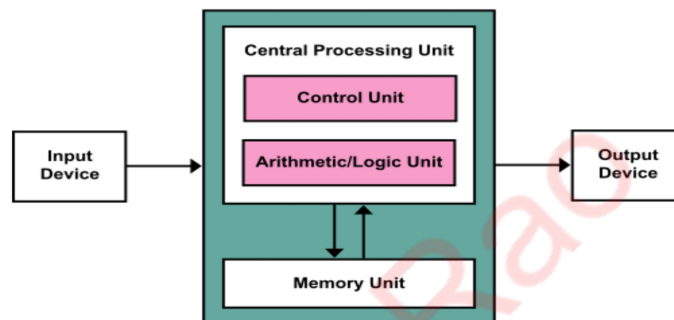

The main features of fifth generation are -

- ULSI technology
- Advancement in Parallel Processing
- More user-friendly interfaces with multimedia features
- Availability of very powerful and compact computers at cheaper rates

Some computer types of this generation are –

- Desktop
- Laptop
- NoteBook
- UltraBook
- ChromeBook

Components of Computer

Input Unit

This unit contains devices with the help of which we enter data into the computer. This unit creates a link between the user and the computer. The input devices translate the information into a form understandable by the computer.

CPU (Central Processing Unit)

CPU is considered as the brain of the computer. CPU performs all types of data processing operations. It stores data, intermediate results, and instructions (program). It controls the operation of all parts of the computer.

CPU itself has the following three components –

- ALU (Arithmetic Logic Unit)
- Memory Unit
- Control Unit

Output Unit

The output unit consists of devices with the help of which we get the information from the computer. This unit is a link between the computer and the users. Output devices translate the computer's output into a form understandable by the users.

Components of CPU

Central Processing Unit (CPU) consists of the following features –

- CPU is considered as the brain of the computer.
- CPU performs all types of data processing operations.
- It stores data, intermediate results, and instructions (program).
- It controls the operation of all parts of the computer.

The CPU itself has the following three components.

- Memory or Storage Unit
- Control Unit
- ALU(Arithmetic Logic Unit)
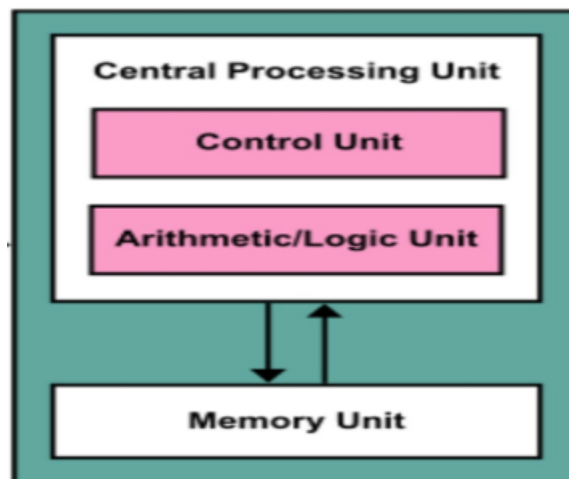
Memory or Storage Unit

This unit can store instructions, data, and intermediate results. This unit supplies information to other units of the computer when needed. It is also known as the internal storage unit or the main memory or the primary storage. Its size affects speed, power, and capability. Primary memory and secondary memory are two types of memories in the computer.

Functions of the memory unit are –

- It stores all the data and the instructions required for processing.
- It stores intermediate results of processing.
- It stores the final results of processing before these results are released to an output device.
- All inputs and outputs are transmitted through the main memory.

Control Unit

This unit controls the operations of all parts of the computer but does not carry out any actual data processing operations.

Functions of this unit are –

- It is responsible for controlling the transfer of data and instructions among other units of a computer.
- It manages and coordinates all the units of the computer.
- It obtains the instructions from the memory, interprets them, and directs the operation of the computer.
- It communicates with Input/Output devices for transfer of data or results from storage.
- It does not process or store data.

ALU (Arithmetic Logic Unit)

This unit consists of two subsections namely,

- Arithmetic Section
- Logic Section

Arithmetic Section

Function of the arithmetic section is to perform arithmetic operations like addition, subtraction, multiplication, and division. All complex operations are done by making repetitive use of the above operations.

Logic Section

Function of the logic section is to perform logic operations such as comparing, selecting, matching, and merging of data.

Memory

- A memory is just like a human brain. It is used to store data and instructions.
- Computer memory is the storage space in the computer, where data is to be processed and instructions required for processing are stored.
- The memory is divided into a large number of small parts called cells. Each location or cell has a unique address.

Memory hierarchy

The Computer memory hierarchy looks like a pyramid structure which is used to describe the differences among memory types. It separates the computer storage based on hierarchy.
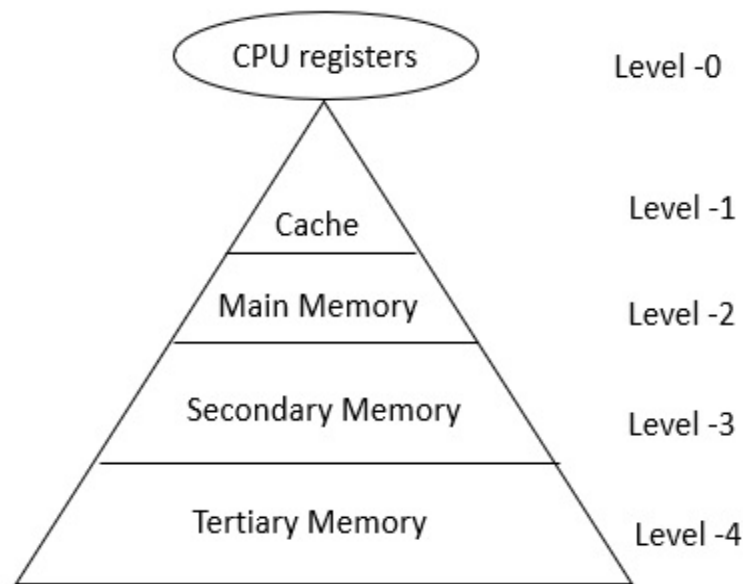
Level 0: CPU registers

Level 1: Cache memory

Level 2: Main memory or primary memory

Level 3: Magnetic disks or secondary memory

Level 4: Optical disks or magnetic types or tertiary Memory

In Memory Hierarchy the cost of memory, capacity is inversely proportional to speed. Here the devices are arranged in a manner Fast to slow, that is from register to Tertiary memory.

Level-0 - Registers
- The registers are present inside the CPU. As they are present inside the CPU, they have least access time.
- Registers are most expensive and smallest in size generally in kilobytes.
- They are implemented by using Flip-Flops.

Level-1 - Cache
- Cache memory is used to store the segments of a program that are frequently accessed by the processor.
- It is expensive and smaller in size generally in Megabytes and is implemented by using static RAM.

Level-2 - Primary or Main Memory
- It directly communicates with the CPU and with auxiliary memory devices through an I/O processor.
- Main memory is less expensive than cache memory and larger in size generally in Gigabytes.

- This memory is implemented by using dynamic RAM.

Level-3 - Secondary storage

- Secondary storage devices like Magnetic Disk are present at level 3.
- They are used as backup storage.
- They are cheaper than main memory and larger in size generally in a few TB.

Level-4 - Tertiary storage

- Tertiary storage devices like magnetic tape are present at level 4.
- They are used to store removable files and are the cheapest and largest in size (1-20 TB).

Types of Memory

Memory is primarily of three types -

- Cache Memory
- Primary Memory/Main Memory
- Secondary Memory

Cache Memory

- Cache memory is a very high speed semiconductor memory which can speed up the CPU.
- It acts as a buffer between the CPU and the main memory.
- It is used to hold those parts of data and programs which are most frequently used by the CPU.
- The parts of data and programs are transferred from the disk to cache memory by the operating system, from where the CPU can access them.

Advantages

The advantages of cache memory are as follows -

- Cache memory is faster than main memory.
- It consumes less access time as compared to main memory.
- It stores the program that can be executed within a short period of time.
- It stores data for temporary use.

Disadvantages

The disadvantages of cache memory are as follows -

- Cache memory has limited capacity.
- It is very expensive.

Primary Memory (Main Memory)

Primary memory holds only those data and instructions on which the computer is currently working. It has a limited capacity and data is lost when power is switched off. It is generally made up of semiconductor devices. These memories are not as fast as registers. The data and instruction required to be processed resides in the main memory. It is divided into two subcategories RAM and ROM.

The major differences between RAM and ROM are:

RAM	ROM
Definition of RAM is Random Access Memory	Definition of ROM is Read-only Memory
Random Access Memory (RAM) is	The speed of Read-only Memory (ROM)

expensive when compared to ROM	is slower when compared to RAM.
Data in RAM can be modified, erased, or read.	Data in ROM can only be read, it cannot be modified or erased.
The data stored in RAM is used by the Central Processing Unit (CPU) to process current instructions	The data stored in ROM is used to bootstrap the computer.
Data of RAM is very volatile, it will exist as long as there is no interruption in power.	Data present in Read-Only Memory (ROM) is not volatile, it is permanent. Data will remain unchanged even when there is a disruption in the power supply.
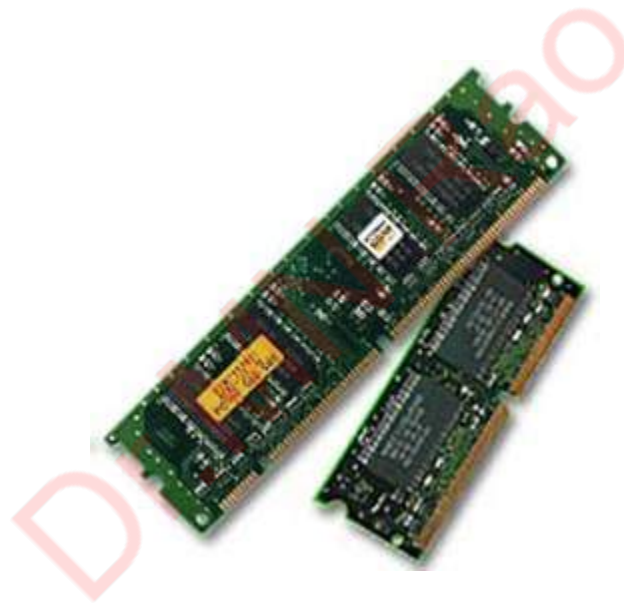
Characteristics of Main Memory

- These are semiconductor memories.
- It is known as the main memory.
- Usually volatile memory.
- Data is lost in case power is switched off.
- It is the working memory of the computer.
- Faster than secondary memories.
- A computer cannot run without the primary memory.

Secondary Memory

This type of memory is also known as external memory or non-volatile.

It is slower than the main memory. These are used for storing data/information permanently. CPU directly does not access these memories, instead they are accessed via input-output routines. The contents of secondary memories are first transferred to the main memory, and then the CPU can access it. For example, disk, CD-ROM, DVD, etc.

Characteristics of Secondary Memory

- These are magnetic and optical memories.
- It is known as the backup memory.
- It is a non-volatile memory.
- Data is permanently stored even if power is switched off.
- It is used for storage of data in a computer.
- Computers may run without the secondary memory.
- Slower than primary memories.

Hardware

- Hardware represents the physical and tangible components of a computer, i.e. the components that can be seen and touched.

Examples of Hardware are the following –

- Input devices – keyboard, mouse, etc.
- Output devices – printer, monitor, etc.
- Secondary storage devices – Hard disk, CD, DVD, etc.
- Internal components – CPU, motherboard, RAM, etc.

Input Devices

Following are some of the important input devices which are used in a computer –

- Keyboard
- Mouse
- Joystick
- Light pen
- Track Ball
- Scanner
- Graphic Tablet
- Microphone
- Magnetic Ink Card Reader(MICR)
- Optical Character Reader(OCR)
- Barcode Reader
- Optical Mark Reader(OMR)

Keyboard

- Keyboard is the most common and very popular input device which helps to input data to the computer.
- The layout of the keyboard is like that of a traditional typewriter, although there are some additional keys provided for performing additional functions.

Mouse

- Mouse is the most popular pointing device. It is a very famous cursor-control device having a small palm size box with a round ball at its base, which senses the movement of the mouse and sends corresponding signals to the CPU when the mouse buttons are pressed.
- Generally, it has two buttons called the left and the right button and a wheel is present between the buttons. A mouse can be

used to control the position of the cursor on the screen, but it cannot be used to enter text into the computer.

Joystick

- Joystick is also a pointing device, which is used to move the cursor position on a monitor screen.
- It is a stick having a spherical ball at its both lower and upper ends.
- The lower spherical ball moves in a socket.
- The joystick can be moved in all four directions.
- It is mainly used in Computer Aided Designing (CAD) and playing computer games.

Light Pen

- Light pen is a pointing device similar to a pen. It is used to select a displayed menu item or draw pictures on the monitor screen.
- It consists of a photocell and an optical system placed in a small tube.
- When the tip of a light pen is moved over the monitor screen and the pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the

CPU.

Track Ball

- Track ball is an input device that is mostly used in a notebook or laptop computer, instead of a mouse.
- This is a ball which is half inserted and by moving fingers on the ball, the pointer can be moved.
- Since the whole device is not moved, a trackball requires less space than a mouse. A track ball comes in various shapes like a ball, a button, or a square.

Scanner

- A Scanner is an input device, which works more like a photocopy machine.
- It is used when some information is available on paper and it is to be transferred to the hard disk of the computer for further manipulation.
- Scanner captures images from the source which are then converted into a digital form that can be stored on the disk.

Magnetic Ink Card Reader (MICR)

● MICR input device is generally used in banks as there are a large number of cheques to be processed every day.

● The bank's code number and cheque number are printed on the cheques with a special type of ink that contains particles of magnetic material that are machine readable.

● This reading process is called Magnetic Ink Character Recognition (MICR).

● The main advantages of MICR is that it is fast and less error prone.

Optical Character Reader (OCR)

● OCR is an input device used to read a printed text.

● OCR scans the text optically, character by character, converts them into a machine readable code, and stores the text on the system memory.

Bar Code Readers

- Bar Code Reader is a device used for reading bar coded data (data in the form of light and dark lines).
- Bar coded data is generally used in labeling goods, numbering the books, etc.
- It may be a handheld scanner or may be embedded in a stationary scanner.
- Barcode Reader scans a barcode image, converts it into an alphanumeric value, which is then fed to the computer that the bar code reader is connected to.

Optical Mark Reader (OMR)
- OMR is a special type of optical scanner used to recognize the type of mark made by pen or pencil.
- It is used where one out of a few alternatives is to be selected and marked.
- It is specially used for checking the answer sheets of examinations having multiple choice questions.

Output Devices
Following are some of the important output devices used in a computer.
- ❖ Monitors

❖ Printer

Monitors

- Monitors, commonly called Visual Display Unit (VDU), are the main output device of a computer.
- It forms images from tiny dots, called pixels that are arranged in a rectangular form.
- The sharpness of the image depends upon the number of pixels.

There are two kinds of viewing screens used for monitors.

❖ Cathode-Ray Tube (CRT)

❖ 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.
- 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 -

- Large in Size
- High power consumption

Flat-Panel Display Monitor

- The flat-panel display refers to a class of video devices that have reduced volume, weight and power requirement in comparison to the CRT.

- You can hang them on walls or wear them on your wrists.
- Current uses of flat-panel displays include calculators, video games, monitors, laptop computer, and graphics display.

The flat-panel display is divided into two categories –

- ❖ Emissive Displays – Emissive displays are devices that convert electrical energy into light. For example, plasma panels and LED (Light-Emitting Diodes).
- ❖ Non-Emissive Displays – Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. For example, LCD (Liquid-Crystal Device).

Printers

Printer is an output device, which is used to print information on paper.

There are two types of printers –

- Impact Printers
- Non-Impact Printers

Impact Printers

Impact printers print the characters by striking them on the ribbon, which is then pressed on the paper.

Characteristics of Impact Printers are the following –

- Very low consumable 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-** which print one character at a time.
  Types: Dot Matrix Printer(DMP), Daisy Wheel
- **Line printers -** which print one line at a time.
  Types: Drum Printer, Chain Printer

Non-impact Printers

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

These printers are of two types –
- ❖ Laser Printers
- ❖ Inkjet Printers

Laser Printers
- They use laser lights to produce the dots needed to form the characters to be printed on a page.

Advantages
- ❖ Very high speed
- ❖ Very high quality output
- ❖ Good graphics quality
- ❖ Supports many fonts and different character size

Inkjet Printers

- They print characters by spraying small drops of ink onto paper.
- Inkjet printers produce high quality output with presentable features.
- They make less noise because no hammering is done and these have many styles of printing modes available.
- Color printing is also possible.
- Some models of Inkjet printers can produce multiple copies of printing also.

Advantages

- ❖ High quality printing
- ❖ More reliable

Software

- Software is a set of programs, which is designed to perform a well-defined function.
- A program is a sequence of instructions written to solve a particular problem.

There are two types of software −

- ❖ System Software

❖   Application Software

System Software

● The system software is a collection of programs designed to operate, control, and extend the processing capabilities of the computer itself.

● System software is generally prepared by the computer manufacturers.

● These software products consist of programs written in low-level languages, which interact with the hardware at a very basic level.

● System software serves as the interface between the hardware and the end users.

● Some examples of system software are Operating System, Compilers, Interpreter, Assemblers, etc.

Application Software

● Application software products are designed to satisfy a particular need of a particular environment.

● All software applications prepared in the computer lab can come under the category of Application software.

● Application software may consist of a single program, such as Microsoft's notepad for writing and editing a simple text.

● It may also consist of a collection of programs, often called a software package, which work together to accomplish a task, such as a spreadsheet package.

Examples of Application software are the following –

- Payroll Software
- Student Record Software
- Inventory Management Software
- Income Tax Software
- Railways Reservation Software
- Microsoft Office Suite Software
- Microsoft Word
- Microsoft Excel
- Microsoft PowerPoint