

Computer Fundamentals

Computer is an electronic device that is designed to work with Information. *The term [computer](#) is derived from the Latin term 'computare', this means to calculate or programmable machine.* **Computer can not do anything without a Program.** It represents the decimal numbers through a string of binary digits. The Word 'Computer' usually refers to the [Center Processor](#) Unit plus Internal [memory](#).

Computer is an advanced electronic device that takes raw data as input from the user and processes it under the control of set of instructions (called program), gives the result (output), and saves it for the future use.

This Computer Fundamentals tutorial covers a foundational understanding of computer hardware, software, operating systems, peripherals etc. along with how to get the most value and impact from computer technology.

Computer - Overview

Today's world is an information-rich world and it has become a necessity for everyone to know about computers. Purpose of this tutorial is to introduce you about computer and its fundamentals.

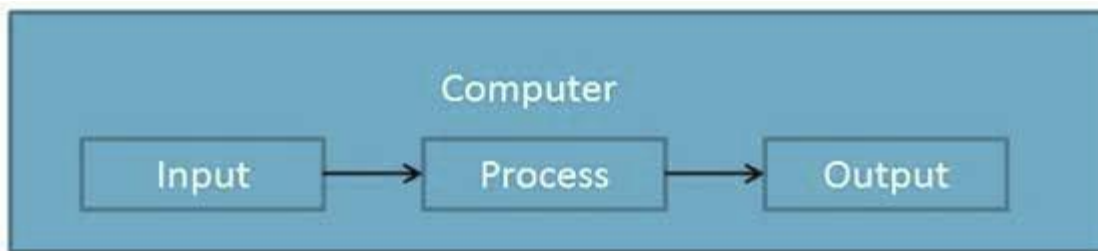
Functionalities of a computer

Any digital computer carries out five functions in gross terms:

- Takes data as input.
- Stores the data/instructions in its memory and use them when required. •

Processes the data and converts it into useful information.

- Generates the output
- Controls all the above four steps.



Definition

Computer is an electronic data processing device which

- accepts and stores data input,
- processes the data input, and

- generates the output in a required format.

Advantages

Following list demonstrates the advantages of computers in today's arena.

High Speed

- Computer is a very fast device.
- It is capable of performing calculation of very large amount of data.
- The computer has units of speed in microsecond, nanosecond, and even the picosecond.
- It can perform millions of calculations in a few seconds as compared to man who will spend many months for doing 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 correct input has been given.

Storage Capability

- Memory is a very important characteristic of computers.
- A computer has much more storage capacity than human beings. ·

It can store large amount of data.

- It can store any type of data such as images, videos, text, audio and many others.

Diligence

- Unlike human beings, a computer is free from monotony, tiredness and lack of concentration. ·

It can work continuously without any error and boredom.

- It can do repeated work with same speed and accuracy.

Versatility

- A computer is a very versatile machine.
- A computer is very flexible in performing the jobs to be done.
- This machine can be used to solve the problems related to various fields.
- 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.

Automation

- Computer is an automatic machine.
- Automation means ability to perform the given task automatically.
- Once a program is given to computer i.e., stored in computer memory, the program and instruction can control the program execution without human interaction.

Reduction in Paper Work

- The use of computers for data processing in an organization leads to reduction in paper work and results in speeding up a process.
- As data in electronic files can be retrieved as and when required, the problem of maintenance of large number of paper files gets reduced.

Reduction in Cost

- Though the initial investment for installing a computer is high but it substantially reduces the cost of each of its transaction.

Disadvantages

Following list demonstrates the disadvantages of computers in today's arena

No I.Q

- A computer is a machine that has no intelligence to perform any task. ·
Each instruction has to be given to computer.
- A computer cannot take any decision on its own.

Dependency

- It functions as per a user's instruction, so it is fully dependent on human being

Environment

- The operating environment of computer should be dust free and suitable.

No Feeling

- Computers have no feelings or emotions.
- It cannot make judgement based on feeling, taste, experience, and knowledge unlike a human being.

Computer - Applications

Following list demonstrates various applications of computers in today's arena.

Business

A computer has high speed of calculation, diligence, accuracy, reliability, or versatility which made it an integrated part in all business organisations.

Computer is used in business organisations for:

- Payroll calculations
- Budgeting
- Sales analysis
- Financial forecasting
- Managing employees database
- Maintenance of stocks etc.

Banking

Today banking is almost totally dependent on computer.

Banks provide following facilities:

- Banks provide online accounting facility, which includes current balances, deposits, overdrafts, interest charges, shares, and trustee records.
- ATM machines are making it even easier for customers to deal with banks.

Insurance

Insurance companies are keeping all records up-to-date with the help of computers. The insurance companies, finance houses and stock broking firms are widely using computers for their concerns.

Insurance companies are maintaining a database of all clients with information showing

- procedure to continue with policies
- starting date of the policies
- next due installment of a policy
- maturity date
- interests due
- survival benefits
- bonus

Education

The computer has provided a lot of facilities in the education system.

- The computer provides a tool in the education system known as CBE (Computer Based Education). CBE involves control, delivery, and evaluation of learning.
- The computer education is rapidly increasing the graph of number of computer students.
- There are number of methods in which educational institutions can use computer to educate the students.
- It is used to prepare a database about performance of a student and analysis is carried out on this basis.

Marketing

In marketing, uses of computer are following:

- **Advertising** - With computers, advertising professionals create art and graphics, write and revise copy, and print and disseminate ads with the goal of selling more products.
- **At Home Shopping** - Home shopping has been made possible through use of computerised catalogues that provide access to product information and permit direct entry of orders to be filled by the customers.

Health Care

Computers have become important part in hospitals, labs, and dispensaries. The computers are being used in hospitals to keep the record of patients and medicines. It is also used in scanning and diagnosing different diseases. ECG, EEG, Ultrasounds and CT Scans etc., are also done by computerised machines.

Some major fields of health care in which computers are used are:

- **Diagnostic System** - Computers are used to collect data and identify cause of illness.
- **Lab-diagnostic System** - All tests can be done and reports are prepared by computer.
- **Patient Monitoring System** - These are used to check patient's signs for abnormality such as in Cardiac Arrest, ECG etc.
- **Pharma Information System** - Computer checks Drug-Labels, Expiry dates, harmful drug's side effects etc.
- **Surgery** : Nowadays, computers are also used in performing surgery.

Engineering Design

Computers are widely used in Engineering purpose.

One of major areas is CAD (Computer aided design). That provides creation and modification of images. Some fields are:

- **Structural Engineering** - Requires stress and strain analysis for design of Ships, Buildings, Budgets, Airplanes etc.
- **Industrial Engineering** - Computers deal with design, implementation and improvement of integrated systems of people, materials and equipments.
- **Architectural Engineering** - Computers help in planning towns, designing buildings, determining a range of buildings on a site using both 2D and 3D drawings.

Military

Computers are largely used in defence. Modern tanks, missiles, weapons etc. Military also employs computerised control systems. Some military areas where a computer has been used are:

- Missile Control
- Military Communication
- Military Operation and Planning
- Smart Weapons

Communication

Communication means to convey a message, an idea, a picture or speech that is received and understood clearly and correctly by the person for whom it is meant for. Some main areas in this category are:

- E-mail
- Chatting
- Usenet
- FTP
- Telnet
- Video-conferencing

Government

Computers play an important role in government. Some major fields in this category are:

- Budgets
- Sales tax department
- Income tax department
- Male/Female ratio
- Computerization of voters lists
- Computerization of driving licensing system
- Computerization of PAN card
- Weather forecasting
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Computer Generations

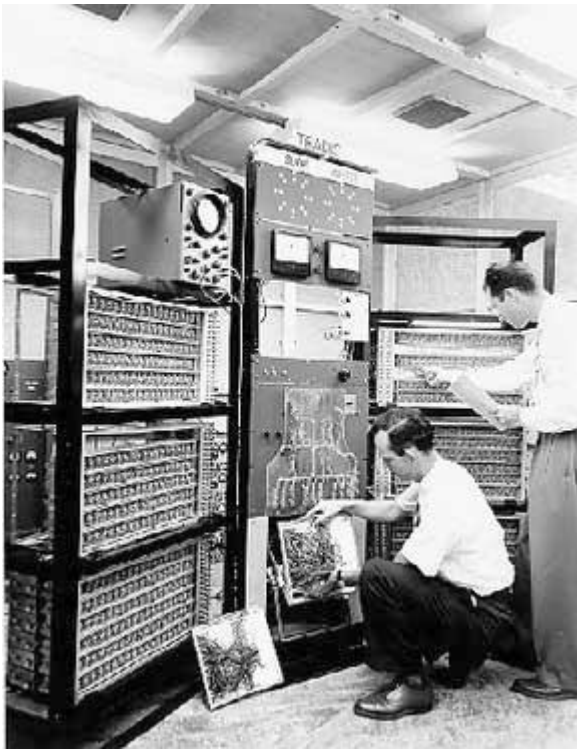
Generation in computer terminology is a change in technology a computer is/was being used. Initially, the generation term was used to distinguish between varying hardware technologies. But nowadays, generation includes both hardware and software, which together make up an entire computer system.

There are totally five computer generations known till date. Each generation has been discussed in detail along with their time period and characteristics. Here approximate dates against each generations have been mentioned which are normally accepted.

Following are the main five generations of computers

Computer - First Generation

The period of first generation was 1946-1959. The computers of 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 were prone to frequent fusing of the installations, therefore, were very expensive and could be afforded only by very large organisations. In this generation mainly batch processing operating system were used. Punched cards, paper tape, and magnetic tape were used as input and output devices. The computers in this generation used machine code as programming language.



The main features of first generation are:

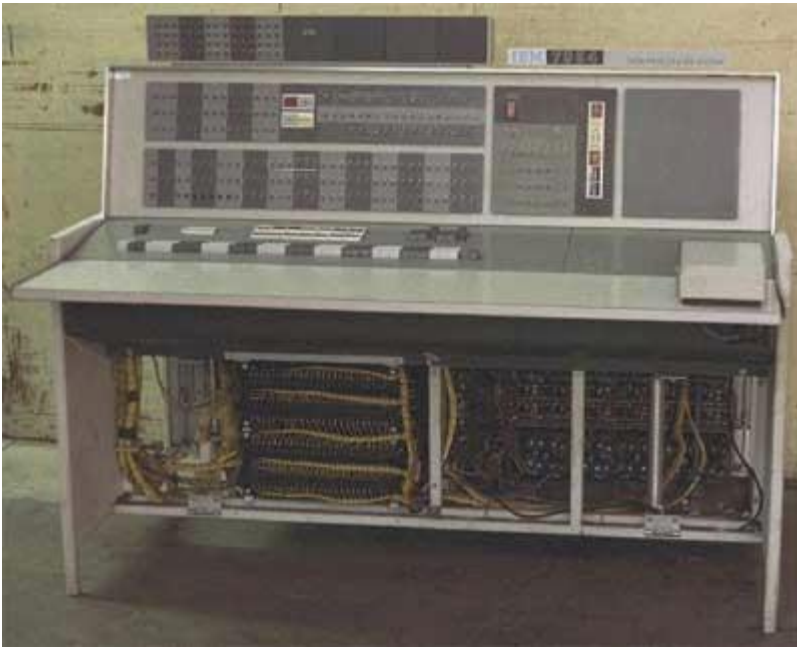
- Vacuum tube technology
- Unreliable
- Supported machine language only
- Very costly
- Generated lot of heat
- Slow input and output devices
- Huge size
- Need of A.C.
- Non-portable
- Consumed lot of electricity

Some computers of this generation were:

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

Computer - Second Generation

The period of second generation was 1959-1965. 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 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 system.



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
- A.C. needed
- Supported machine and assembly languages

Some computers of this generation were:

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

Computer - Third Generation

The period of third generation was 1965-1971. The computers of third generation used integrated circuits (IC's) 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, multi-programming operating system 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
- Still costly
- A.C needed
- 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

Computer - Fourth Generation

The period of fourth generation was 1971-1980. The computers of fourth generation used Very Large Scale Integrated (VLSI) circuits. VLSI circuits having about 5000 transistors and other circuit elements and 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 personal computer (PC) revolution. In this generation time sharing, real time, networks, distributed operating system 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 PC's
- Very small size
- Pipeline processing
- No A.C. needed
- 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(Super Computer)
- CRAY-X-MP(Super Computer)

Computer - Fifth Generation

fifth generation is 1980-till date. In the fifth generation, the 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 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.

AI includes:

- Robotics
- Neural Networks
- Game Playing
- Development of expert systems to make decisions in real life situations. •
Natural language understanding and generation.



The main features of fifth generation are:

- ULSI technology
- Development of true artificial intelligence
- Development of Natural language processing
- Advancement in Parallel Processing
- Advancement in Superconductor technology
- 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

CLASSIFICATION OF COMPUTERS

Computers differ based on their data processing abilities. They are classified according to purpose, data handling and functionality.

According to purpose, computers are either general purpose or specific purpose. **General purpose computers** are designed to perform a range of tasks. They have the ability to store numerous programs, but lack in speed and efficiency. Specific purpose computers are designed to handle a specific problem or to perform a specific task. A set of instructions is built into the machine.

According to data handling, computers are analog, digital or hybrid. Analog computers work on the principle of measuring, in which the measurements obtained are translated into data. Modern analog computers usually employ electrical parameters, such as voltages, resistances or currents, to represent the quantities being manipulated. Such computers do not deal directly with the numbers. They measure continuous physical magnitudes. Digital computers are those that operate with information, numerical or otherwise, represented in a digital form. Such computers process data into a digital value (in 0s and 1s). They give the results with more accuracy and at a faster rate. Hybrid computers incorporate the measuring feature of an analog computer and counting feature of a digital computer. For computational purposes, these computers use analog components and for storage, digital memories are used.

According to functionality, computers are classified as :

Analog Computer

An analog computer (spelt analogue in British English) is a form of computer that uses continuous physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved.

Digital **Computer**

A computer that performs calculations and logical operations with quantities represented as digits, usually in the binary number system

Hybrid Computer (Analog + Digital)

A combination of computers those are capable of inputting and outputting in both digital and analog signals. A hybrid computer system setup offers a cost effective method of performing complex simulations.

On the basis of Size

Super Computer

The fastest and most powerful type of computer Supercomputers are very expensive and are employed for specialized applications that require immense amounts of mathematical calculations. For example, weather forecasting requires a supercomputer. Other uses of supercomputers include animated graphics, fluid dynamic calculations, nuclear energy research, and petroleum exploration.

The chief difference between a supercomputer and a mainframe is that a supercomputer channels all its power into executing a few programs as fast as possible, whereas a mainframe uses its power to execute many programs concurrently.

Mainframe Computer

A very large and expensive computer capable of supporting hundreds, or even thousands, of users simultaneously. In the hierarchy that starts with a simple microprocessor (in watches, for example) at the bottom and moves to supercomputers at the top, mainframes are just below supercomputers. In some ways, mainframes are more powerful than supercomputers because they support more simultaneous programs. But supercomputers can execute a single program faster than a mainframe.

Mini Computer

A midsized computer. In size and power, minicomputers lie between workstations and mainframes. In the past decade, the distinction between large minicomputers and small mainframes has blurred, however, as has the distinction between small minicomputers and workstations. But in general, a minicomputer is a multiprocessing system capable of supporting from 4 to about 200 users simultaneously.

Micro Computer or Personal Computer

- **Desktop Computer:** a personal or micro-mini computer sufficient to fit on a desk.
- **Laptop Computer:** a portable computer complete with an integrated screen and keyboard. It is generally smaller in size than a desktop computer and larger than a notebook computer.
- **Palmtop Computer/Digital Diary /Notebook /PDAs:** a hand-sized computer. Palmtops have no keyboard but the screen serves both as an input and output device.

Workstations

A terminal or desktop computer in a network. In this context, workstation is just a generic term for a user's machine (client machine) in contrast to a "server" or "mainframe."

OR

CLASSES OF COMPUTER

There are four classes of computer which include:-

- a) Micro Computer.
- b) Mini Computer.
- c) Mainframe Computer

d) Super Computer

- a) **MICRO COMPUTER:** this is the forth generations of PC's, manufactured in the 70s. they are smaller and cheaper (meaning smaller in size). They are also referred to as PC (personal computer) or work station. The liked of the PC's are laptop, palmtop, hand held/pocket size pc.
- b) **MINI COMPUTER:** It is physically larger than the micro computer, it was develop for the use of the military and was used before the arrival of the micro computers. Today, mini PC's are being used in an organization where large amount of data are processed, they can serve a number ranging up to 40,000 users. It is very expensive most modern armies have mini computers which are used on the battle field to process large amount of data's received from satellite e.g. Hp1000, DG900, PDP11 and PD8-/E.
- c) **MAINFRAME COMPUTERS:** It processes vast amount of datas. IBM is a major supplier. They are very large and have to be housed in a special room whose temperature and humidity are low. It is very expensive and is avoidable mostly by multinational companies and government parastatal. It processes a very large amount data in seconds and respond to thousand of users simultaneously.
- d) **SUPER COMPUTERS:** It processes large gigantic data in the quickest possible time and very expensive to buy. They are commonly used by spaces center worldwide.

BLOCK DIAGRAM OF COMPUTER AND EXPLAIN ITS VARIOUS COMPONENTS

A [computer](#) can process data, pictures, sound and graphics. They can solve highly complicated problems quickly and accurately. A computer as shown in Fig. performs basically five major computer operations or functions irrespective of their size and make. These are

- 1) it accepts data or instructions by way of input,
- 2) it stores data,
- 3) it can process data as required by the user,
- 4) it gives results in the form of output, and

5) it controls all operations inside a computer.

We discuss below each of these Computer operations

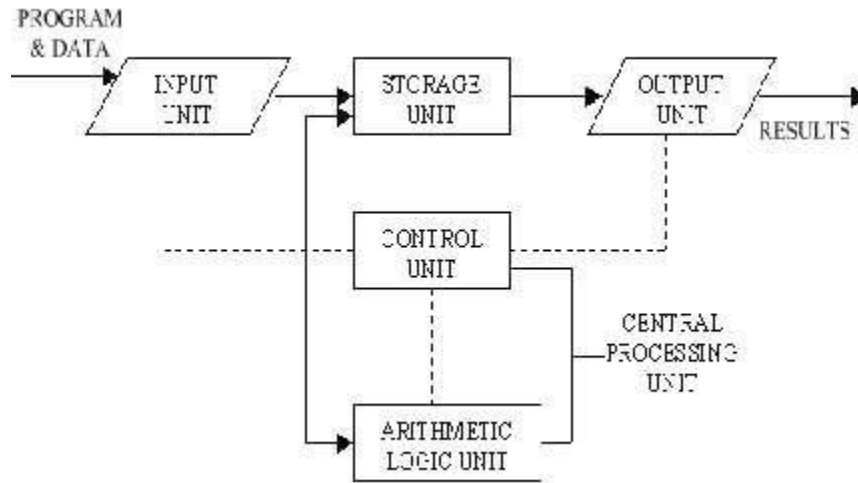


Fig : Basic computer Operations

Input Unit

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

CPU itself has following three components

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

Output Unit

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

Computer - CPU(Central Processing Unit)

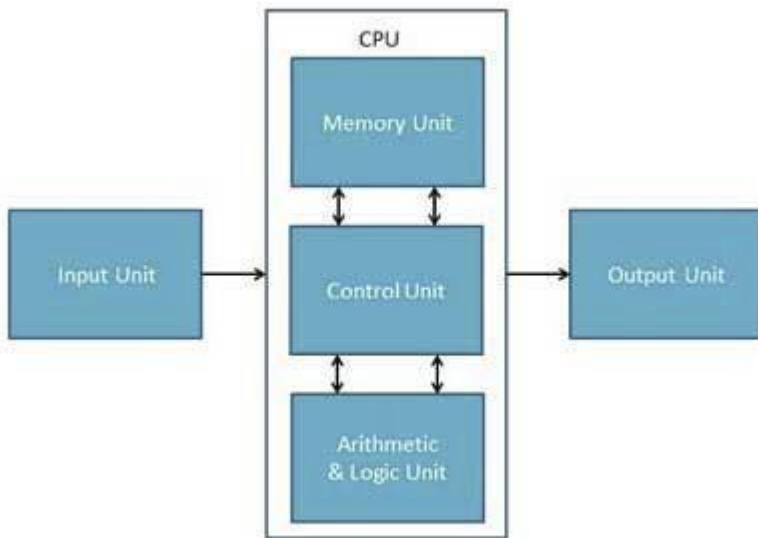
CPU consists of the following features:

- 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 computer.



CPU itself has 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 the other units of the computer when needed. It is also known as internal storage unit or main memory or primary storage or Random access memory(RAM).

Its size affects speed, power and capability. Primary memory and secondary memory are two types of memories in the computer. Functions of memory unit are:

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

Control Unit

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

Logic Section

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

Computer - Input Devices

Following are few of the important input devices which are used in a computer:

- Keyboard
- Mouse
- Joy Stick
- Light pen
- Track Ball
- Scanner
- Graphic Tablet
- Microphone
- Magnetic Ink Card Reader(MICR)
- Optical Character Reader(OCR)
- Bar Code Reader
- Optical Mark Reader(OMR)

Keyboard

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

Keyboards are of two sizes 84 keys or 101/102 keys, but now keyboards with 104 keys or 108 keys are also available for Windows and Internet.

The keys on the keyboard are as follows:

Sr.No	Keys	Description
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1	Typing Keys	These keys include the letter keys (A-Z) and digit keys (0-9) which generally give same layout as that of typewriters.
2	Numeric Keypad	It is used to enter numeric data or cursor movement. Generally, it consists of a set of 17 keys that are laid out in the same configuration used by most adding machines and calculators.
3	Function Keys	The twelve function keys are present on the keyboard which are arranged in a row at the top of the keyboard. Each function key has unique meaning and is used for some specific purpose.
4	Control keys	These keys provide cursor and screen control. It includes four directional arrow keys. Control keys also include Home, End, Insert, Delete, Page Up, Page Down, Control(Ctrl), Alternate(Alt), Escape(Esc).
5	Special Purpose Keys	Keyboard also contains some special purpose keys such as Enter, Shift, Caps Lock, Num Lock, Space bar, Tab, and Print Screen.



Mouse

Mouse is 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 mouse and sends corresponding signals to CPU when the mouse buttons are pressed.

Generally it has two buttons called left and right button and a wheel is present between the buttons. Mouse can be used to control the position of cursor on screen, but it cannot be used to enter text into the computer.

Advantages

- Easy to use
- Not very expensive

- Moves the cursor faster than the arrow keys of keyboard.



Joystick

Joystick is also a pointing device which is used to move 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.

The function of joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing(CAD) and playing computer games.



Light Pen

Light pen is a pointing device which is 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 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 notebook or laptop computer, instead of a mouse. This is a ball which is half inserted and by moving fingers on ball, pointer can be moved. Since the whole device is not moved, a track ball requires less space than a mouse. A track ball comes in various shapes like a ball, a button and a square.



Scanner

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



Digitizer

Digitizer is an input device which converts analog information into digital form. Digitizer can convert a signal from the television or camera into a series of numbers that could be stored in a computer. They can be used by the computer to create a picture of whatever the camera had been pointed at. Digitizer is also known as Tablet or Graphics Tablet because it converts graphics and pictorial data into binary inputs. A graphic tablet as digitizer is used for doing fine works of drawing and image manipulation applications.



Microphone

Microphone is an input device to input sound that is then stored in digital form. The microphone is used for various applications like adding sound to a multimedia presentation or for mixing music.



Magnetic Ink Card Reader(MICR)

MICR input device is generally used in banks because of 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 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 form of light and dark lines). Bar coded data is generally used in labelling goods, numbering the books etc. It may be a hand held scanner or may be embedded in a stationary scanner. Bar Code Reader scans a bar code image, converts it into an alphanumeric value which is then fed to the computer to which bar code reader is connected.



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.



Computer - Output Devices

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

- Monitors
- Graphic Plotter
- Printer

Monitors

Monitors, commonly called as 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 screen 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. It takes more than one illuminated pixel to form whole character, such as the letter 'e' in the word help.

A finite number of characters can be displayed on a screen at once. The screen can be divided into a series of character boxes - fixed location on the screen where a standard character can be placed. Most screens are capable of displaying 80 characters of data horizontally and 25 lines vertically. There are some disadvantages of CRT:

- 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, graphics display.

The flat-panel display is divided into two categories:

- **Emissive Displays** - The emissive displays are devices that convert electrical energy into light. Example are plasma panel and LED(Light-Emitting Diodes).
- **Non-Emissive Displays** - The Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Example is LCD(Liquid-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

The 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
- Line printers

Character Printers

Character printers are the printers which print one character at a time.

These are further divided into two types:

- Dot Matrix Printer(DMP)
- Daisy Wheel

Dot Matrix Printer

In the market one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price. Each character printed is in form of pattern of dots and head consists of a Matrix of Pins of size (5*7, 7*9, 9*7 or 9*9) which come out to form a character that is why it is called Dot Matrix Printer.

Advantages

- Inexpensive
- Widely Used
- Other language characters can be printed

Disadvantages

- Slow Speed
- Poor Quality



Daisy Wheel

Head is lying on a wheel and pins corresponding to characters are like petals of Daisy (flower name) that is why it is called Daisy Wheel Printer. These printers are generally used for word-processing in offices which require a few letters to be sent here and there with very nice quality.

Advantages

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

Disadvantages

- Slower than DMP
- Noisy
- More expensive than DMP



Line Printers

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



These are of further two types

- Drum Printer
- Chain Printer

Drum Printer

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

Advantages

- Very high speed

Disadvantages

- Very expensive
- Characters fonts cannot be changed

Chain Printer

In this printer, chain of character sets are used so it is called Chain Printer. A standard character set may have 48, 64, or 96 characters.

Advantages

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

Disadvantages

- Noisy

Non-impact Printers

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

These printers are of two types

- Laser Printers
- Inkjet Printers

Characteristics of Non-impact Printers

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

Laser Printers

These are non-impact page 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
- Give good graphics quality
- Support many fonts and different character size

Disadvantages

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



Inkjet Printers

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

They make less noise because no hammering is done and these have many styles of printing modes available. Colour printing is also possible. Some models of Inkjet printers can produce multiple copies of printing also.

Advantages

- High quality printing
- More reliable

Disadvantages

- Expensive as cost per page is high
- Slow as compared to laser printer



Computer - Memory

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

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 CPU. It acts as a buffer between the CPU and main memory. It is used to hold those parts of data and program which are most frequently used by

CPU. The parts of data and programs are transferred from disk to cache memory by operating system, from where 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 computer is currently working. It has limited capacity and data is lost when power is switched off. It is generally made up of semiconductor device. These memories are not as fast as registers. The data and instruction required to be processed reside in main memory. It is divided into two subcategories RAM and ROM.

Characteristics of Main Memory

- These are semiconductor memories

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



Secondary Memory

This type of memory is also known as external memory or non-volatile. It is slower than 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. Contents of secondary memories are first transferred to main memory, and then CPU can access it. For example : disk, CD-ROM, DVD etc.

Characteristic of Secondary Memory

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



Computer - Random Access Memory

RAM(Random Access Memory) is the internal memory of the CPU for storing data, program and program result. It is read/write memory which stores data until the machine is working. As soon as the machine is switched off, data is erased.

Access time in RAM is independent of the address that is, each storage location inside the memory is as easy to reach as other locations and takes the same amount of time. Data in the RAM can be accessed randomly but it is very expensive.

RAM is volatile, i.e. data stored in it is lost when we switch off the computer or if there is a power failure. Hence a backup uninterruptible power system(UPS) is often used with computers. RAM is small, both in terms of its physical size and in the amount of data it can hold.

RAM is of two types

- Static RAM (SRAM)
- Dynamic RAM (DRAM)



Static RAM (SRAM)

The word **static** indicates that the memory retains its contents as long as power is being supplied. However, data is lost when the power gets down due to volatile nature. SRAM chips use a matrix of 6-transistors and no capacitors. Transistors do not require power to prevent leakage, so SRAM need not have to be refreshed on a regular basis.

Because of the extra space in the matrix, SRAM uses more chips than DRAM for the same amount of storage space, thus making the manufacturing costs higher. So SRAM is used as cache memory and has very fast access.

Characteristic of the Static RAM

- It has long life
- There is no need to refresh
- Faster
- Used as cache memory
- Large size
- Expensive
- High power consumption

Dynamic RAM (DRAM)

DRAM, unlike SRAM, must be continually **refreshed** in order to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small. All DRAMs are made up of memory cells which are composed of one capacitor and one transistor.

Characteristics of the Dynamic RAM

- It has short data lifetime
- Need to be refreshed continuously
- Slower as compared to SRAM
- Used as RAM
- Lesser in size

- Less expensive
- Less power consumption

Computer - Read Only Memory

ROM stands for Read Only Memory. The memory from which we can only read but cannot write on it. This type of memory is non-volatile. The information is stored permanently in such memories during manufacture. A ROM, stores such instructions that are required to start a computer. This operation is referred to as bootstrap. ROM chips are not only used in the computer but also in other electronic items like washing machine and microwave oven.



Following are the various types of ROM

MROM (Masked ROM)

The very first ROMs were hard-wired devices that contained a pre-programmed set of data or instructions. These kind of ROMs are known as masked ROMs which are inexpensive.

PROM (Programmable Read only Memory)

PROM is read-only memory that can be modified only once by a user. The user buys a blank PROM and enters the desired contents using a PROM program. Inside the PROM chip there are small fuses which are burnt open during programming. It can be programmed only once and is not erasable.

EPROM(Erasable and Programmable Read Only Memory)

The EPROM can be erased by exposing it to ultra-violet light for a duration of up to 40 minutes. Usually, an EPROM eraser achieves this function. During programming, an electrical charge is trapped in an insulated gate region. The charge is retained for more than ten years because the charge has no leakage path. For erasing this charge, ultra-violet light is passed through a quartz crystal window(lid). This exposure to ultra-violet light dissipates the charge. During normal use the quartz lid is sealed with a sticker.

EEPROM(Electrically Erasable and Programmable Read Only Memory)

The EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. Both erasing and programming take about 4 to 10 ms (milli second). In EEPROM, any location can be selectively erased and programmed. EEPROMs can be erased one byte at a time, rather than erasing the entire chip. Hence, the process of re-programming is flexible but slow.

Advantages of ROM

The advantages of ROM are as follows:

- Non-volatile in nature
- These cannot be accidentally changed
- Cheaper than RAMs
- Easy to test
- More reliable than RAMs
- These are static and do not require refreshing
- Its contents are always known and can be verified

SECONDARY STORAGE DEVICES

Auxiliary memory also known as **auxiliary storage**, **secondary storage**, **secondary memory** or **external memory**, is a [non-volatile memory](#) (does not lose stored data when the device is powered down) that is not directly accessible by the CPU, because it is not accessed via the input/output channels (it is an external device). In RAM devices (as flash memory) data can be directly deleted or changed.

It is used to store a large amount of data at lesser cost per byte than [primary memory](#); secondary storage is two orders of magnitude less expensive than primary storage.

The most common forms of auxiliary memory are [flash memory](#), [optical discs](#), [magnetic disks](#) and [magnetic tape](#) . The latest addition to the auxiliary memory family is flash memory. This form is much faster as compared to predecessors, as this form of auxiliary memory does not involve any moving parts. In some laptops, such as Apple's MacBook Air line and MacBook Pro with Retina Display line, [solid state drive](#).

- [Flash memory](#): An electronic non-volatile computer storage device that can be electrically erased and reprogrammed, and works without any moving parts. Examples of this are [flash drives](#), [memory cards](#) and [solidstate drives](#). A version of this is implemented in many Apple notebooks.
- [Optical disc](#): A storage medium from which data is read and written by lasers. Optical disks can store much more data — up to 6 gigabytes more than most portable magnetic media, such as [floppies](#). There are three basic types of optical disks: CD-ROM (read-only), WORM (write-once read-many) & EO (erasable optical disks).
- [Magnetic Disk](#): A magnetic disk is a circular plate constructed of metal or plastic coated with magnetized material. Both sides of the disk are used and several disks may be stacked on one spindle with read/write heads available on each surface. Bits are stored on the magnetized surface in spots along concentric circles called tracks. Tracks are commonly divided into sections called sectors. Disk that are permanently attached and cannot be removed by the occasional user are called hard disks. A disk drive with removable disks is called a floppy disk drive.
- [Magnetic tapes](#): A magnetic tape transport consists of electric, mechanical and electronic components to provide the parts and control mechanism for a magnetic tape unit. The tape itself is a strip of plastic coated with a magnetic recording medium. Bits are recorded as magnetic spots on tape along several tracks. Seven or nine bits are recorded to form a character together with a parity bit. R/W heads are mounted in each track so that data can be recorded and read as a sequence of characters.

Different types of secondary storage devices

There exists different types of secondary storage devices, each of them suitable for a different purpose. They mainly differ in the following aspects:

- Technology used to store data ·
- Capacity of data they can hold ·
- Size of storage device
- Portability of storage device and
- Access time to stored data.

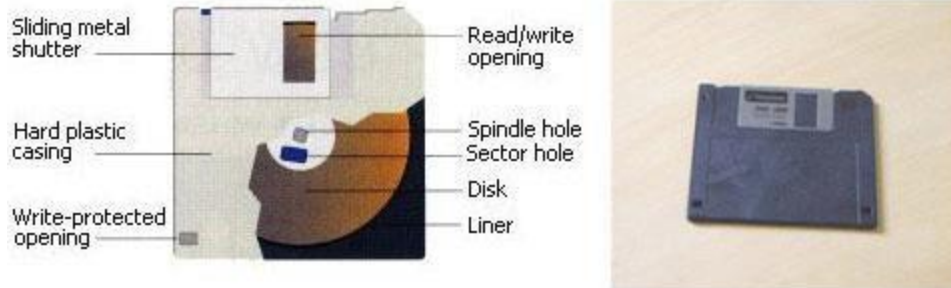
Currently the most common forms of secondary storage device are:

- Floppy disks
- Hard disks
- Optical Disks
- Magnetic Tapes.
- Solid State Devices

Understanding the characteristics of each of them would help you choose the most appropriate storage device to hold your data.

Floppy Disks

Floppy disks often referred to as diskettes have been and are still being widely used to store data of small size.



Floppy disks

They are very easy to use and are portable. They consist of a flat Mylar plastic disk that rotates within a hard plastic casing. Data is stored as electromagnetic charges on a metal oxide film coating the Mylar plastic. Floppy disks also contain a write protect notch that can prevent writing to the disks. There exist several types of floppy disks but the most common one is the 3.5 inch floppy that can store data up to a capacity of 1.44 megabytes, something like 400 typewritten pages. A floppy drive is required to access a floppy disk.



Floppy drive

When the floppy is inserted in the floppy drive, the sliding metal shutter is opened exposing the Mylar plastic and a read-write head moves across the exposed disk to either store or retrieve data. Data is recorded on the disk in closed concentric circles known as **tracks**.



Tracks in floppy disks

Often you will hear of the term **formatting**. This is nothing more than creating these tracks so that your computer can save data properly on these disks. In other cases, formatting also refers to completely removing all contents present inside the floppy. At the time when the computer was first introduced, most documents contained only textual data and hence much information could be saved inside floppy disks. Recently multimedia files (images, sounds and texts), which are quite bulky in size, are becoming more and more popular and may require more than the 1.44Mbytes that a floppy may provide. This is why floppy disks are today only suitable for limited purposes. Some manufacturers are already anticipating the need for higher capacity floppy disks and are thus coming up with **floppy disks cartridges** that will use the same principle as standard floppy disks but providing for higher storage capacities. Some examples include Zip disks, Superdisk and (**HI**gh Capacity **F**loppy **D**isk) HIFD disk.

Description	Capacity
Standard floppy	1.44 MB
Zip	100/250MB
Superdisk	120/250MB
HIFD	200MB

Floppy disks capacities

Taking care of your floppy

The fact that floppy disks can be easily carried from one place to another necessitates extra precautions when handling them. Otherwise you might find yourself losing all data that you have saved in your floppy disk. Here are some guidelines that you need to follow regarding floppy disks.

- Avoid touching the Mylar plastic since it is this part that contains data.
- Do not bend the disk, as this may affect the magnetic characteristic of the disk
- Never remove a floppy while the light of floppy drive is on. Doing so will damage the floppy and data may be lost.
- Do not expose your disks to extreme heat, strong magnetic fields and water. •

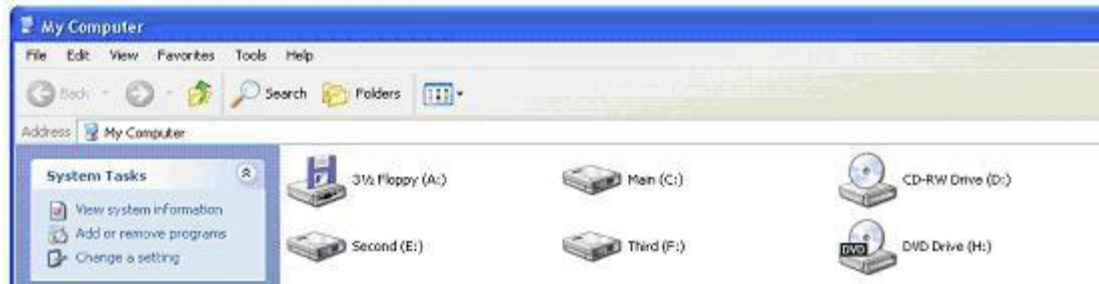
Keep your floppy in dedicated storage boxes.

- Sometimes high humidity may damage floppy disks, so keep them in a dry environment.

But the best protection still is to keep a back up of all your work in a duplicate disk.

Hard Disks

Hard disks differ from floppy disk in that they have been designed to store very high volume of data. Currently hard disks can store gigabytes of data (e.g. 200GB) and they are an integral part of the computer. Most operating systems are stored in hard disks and all materials (application software, documents, images, music files etc) that you save on your computer is stored in the hard disk.



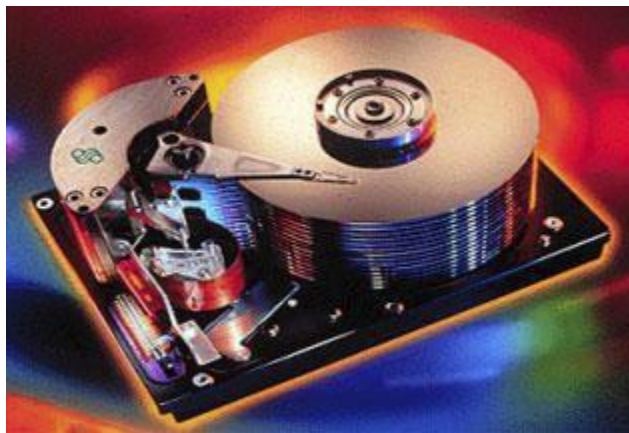
Locating hard disk inside a computer

Locating the (*logical*) hard disk of a computer is very easy and all you have to do is to double click on the “My computer” icon that you see on the start up (desktop) screen of your computer. You should get a window similar to the one shown in. In contrast to floppy disks, data is stored on a metal platter in the form of magnetic spots. The metal platter is sealed inside a disk drive that protects the platter and as well enables reading and writing to the disk. Sometimes some hard disk may fail due to a **head crash**, resulting in loss of data and this is due to various reasons such as: improper handling of hard disks, voltage surge, malfunctioning of read/write head and more.



The inside of a typical hard disk

Similar to floppy disks, data is stored in closed concentric circles called tracks on the platters and a hard disk may contain several platters forming **hard disk packs** that increase the capacity of data that can be stored by the device.



Inside hard disk pack

An interesting feature about hard disks apart from their large data holding capacity is their access time. Hard disks provide fast access both for reading and writing. That is why, it is always faster to open a document present on a hard disk rather than on a floppy

. **Internal and external hard disks**

Most hard disks are specifically designed to be fixed inside a computer (**internal hard disks**), but with advances in technology and user need, hard disks can now be connected externally to a computer (**external hard disk**) via a **USB port**. External hard disks are mostly used for back up purposes and/or transferring of large amount of data. Both internal and external hard disks work under the same principle, however external hard disk delivers slower access time due to its USB interfacing with a computer for data transfer.

Optical Disks

Music CDs (compact disks) form part of a category of storage devices called optical disks. The latter make use of light energy to store information and are very suitable to store information of relatively high capacity (700MB).



A Compact Disk

They come in the form of a thin plastic disk, with a printed label layer on one side and a reflective layer on the other side onto which a high laser beam will read or write data depending on the type of optical disk being used. Computer systems usually have access to these storage media via CD drives that contain a special lens to read and/or write data on the disks.



CD Drive

An interesting characteristic about CD drives is the speed of rotation. Typical speeds range from 12X to 52X. Actually the rotating speed determines the rate at which data is transferred from the computer to the disk and vice versa. A 32X drive will transfer 4.8 MB of data per second compared to 3.6MB of data transfer per second for a 24X drive. The faster the drive therefore, the faster data can be read from the CD and used by the computer. Currently there exist three basic types of CDs that you will surely make much use of: CD-ROM, CD-R, and CD-RW. Basically all of them have the same storage capacity except that they differ from their read-write capability.

1.CD-ROM 1

CD-ROM stands for compact disk read-only memory. They are like commercially available music CDs that allows you to only listen (read) to music without altering the contents of the CD. They are used mostly for selling of music, movies and also for distribution of software packages like Microsoft Office.

2 CD-R

CD-R stands for CD-Recordable that can be written on only once. These are special optical disks that typically come with no data at all in them such that a user can choose to add whatever contents he/she may wish to. Some example applications include creating a back up of your hard disk, creating your own music CD or saving your family album. To do so however, you will need a special CD-RW (read write) drive and appropriate CD burning software.



portion of disk that has got data written on it

.3 CD-RW

Also known as erasable disks, CR-RW (rewritable) can be used to save data several times. Their reflective layer is made up of a special coating that is not permanently altered when data is saved onto them such that they can be erased to accommodate new data. This type of optical disk is particularly useful to save large **files** that need to be updated regularly. Here as well, special CD-RW drive and appropriate burning software is required.

4 DVD

DVD stands for Digital Versatile Disk or Digital Video Disk. They are now commonly used for the distribution of movies since they offer high capacity storage medium with good quality. DVD and CD are very similar in that both make use of light energy to read or write data on their reflective surfaces. However the technology behind DVD allows larger amount of data to be stored compared to CD (4.7-17 Gigabytes of data). Here as well, you will need a special DVD drive for your computer to access the data present inside a DVD.



The DVD trademark

Like CDs, there are three basic types of DVDs.

- **DVD-ROMs** are commercially available DVDs for which the contents cannot be altered. For example, movies are available on DVDs.
- **DVD-R** comes initially as blank DVDs that allow the user to write only once though any useful data, he/she may wish to save. Here as well special DVD-RW drive is required with appropriate DVD burning software.
- **DVD + RW** are very similar to CD-RW as they allow the user to save and erase the disk several times. With the decrease in cost and availability of DVD-RW drives in most computers, these high capacity disks will surely represent a safe and efficient means of saving data.



Reflective surface of a DVD

5 CD/DVD Care

CDs and DVDs need special care in order to ensure that any data saved on them is not lost, just like floppy disks. Some guidelines are as follows:

- Do not expose your CD/DVD to extreme temperature.
- Store them in their casing - any scratch makes it difficult to read through the reflective coating.

Avoid touching the surface of the CD/DVD.

- Do not write on the reflective coating of the CD/DVD and use only recommended marker for any labelling on the label side.
- Clean the CD/DVD with a soft cloth in an outward direction from the centre of the disk avoiding circular movements.

Other secondary storage devices

So far we have seen three common examples of secondary storage devices; floppy disks, hard disks and optical disks. All of them form an integral part of all microcomputers today. They satisfy most of user's need although in some cases, additional devices are required. Two such examples are **magnetic tapes** and **solid-state storage devices**.

1 Magnetic tapes

These have existed for a long time now. They are very similar to the tapes that are used in radio cassette player and video recorders and can still be found in video camcorders.



A magnetic tape

Magnetic tapes provide a very effective means for back up purposes of large amount of data (5 Gigabytes). However the main limitation is that data stored is in a **sequential** mode, that is, you may have to wait for several inches of tape to play before you can reach the data that is of interest to you. Consequently access to the required data is slow. **Direct** access on the other hand allows the user to go directly to the piece of information without having to wait for any prior information to be accessed. A clear example of direct access is when you want to play a track on a music CD and that you only need to select the song you want to listen to. **Magnetic tape cartridges** or **streamers** are used mainly by micro computers whereas **magnetic tape reels** which offer much higher back up capacity are used by mainframes.



A magnetic tape reel

2 Solid state storage devices

Unlike other storage devices discussed so far, solid state storage devices have got no moving parts and data is stored and retrieved from them in a similar manner as it would be from computer memory. They come in different forms and sometimes under different commercial names such as **USB disk, Pen drives, Flash disks** etc. Some manufacturers tend to market these devices by adding components such as mp3 players within the devices and so on. However all of them work with very little power and represent a reliable device having relatively good storage capacity. Typical storage capacity ranges from 32Mb to 1GB.



Typical solid-state storage device

Computer - Motherboard

The motherboard serves as a single platform to connect all of the parts of a computer together. A motherboard connects CPU, memory, hard drives, optical drives, video card, sound card, and other ports and expansion cards directly or via cables. It can be considered as the backbone of a computer.



Features of Motherboard

A motherboard comes with following features:

- Motherboard varies greatly in supporting various types of components.
 - Normally a motherboard supports a single type of CPU and few types of memories.
 - Video Cards, Hard disks, Sound Cards have to be compatible with motherboard to function properly ·
- Motherboards, cases and power supplies must be compatible to work properly together.

Popular Manufacturers

- Intel
- ASUS
- AOpen
- ABIT
- Biostar
- Gigabyte
- MSI

Description of Motherboard

The motherboard is mounted inside the case and is securely attached via small screws through pre-drilled holes. Motherboard contains ports to connect all of the internal components. It provides a single socket for CPU whereas for memory, normally one or more slots are available. Motherboards provide ports to attach floppy drive, hard drive, and optical drives via ribbon cables. Motherboard carries fans and a special port designed for power supply.

There is a peripheral card slot in front of the motherboard using which video cards, sound cards and other expansion cards can be connected to motherboard.

On the left side, motherboards carry a number of ports to connect monitor, printer, mouse, keyboard, speaker, and network cables. Motherboards also provide USB ports which allow compatible devices to be connected in plugin/plug-out fashion for example, pen drive, digital cameras etc.

Computer - Memory Units

Memory unit is:

- the amount of data that can be stored in the storage unit.
- that in which storage capacity is expressed in terms of Bytes.

Following are the main memory storage units:

Sr.No.	Unit	Description
1	Bit (Binary Digit)	A binary digit is logical 0 and 1 representing a passive or an active state of a component in an electric circuit.
2	Nibble	A group of 4 bits is called nibble.
3	Byte	A group of 8 bits is called byte. A byte is the smallest unit which can represent a data item or a character.
4	Word	A computer word, like a byte, is a group of fixed number of bits processed as a unit which varies from computer to computer but is fixed for each computer. The length of a computer word is called word-size or word length and it may be as small as 8 bits or may be as long as 96 bits. A computer stores the information in the form of computer words.

Few higher storage units are following

Sr.No.	Unit	Description
1	Kilobyte (KB)	1 KB = 1024 Bytes
2	Megabyte (MB)	1 MB = 1024 KB
3	GigaByte (GB)	1 GB = 1024 MB
4	TeraByte (TB)	1 TB = 1024 GB
5	PetaByte (PB)	1 PB = 1024 TB

Computer - Ports

What is a Port?

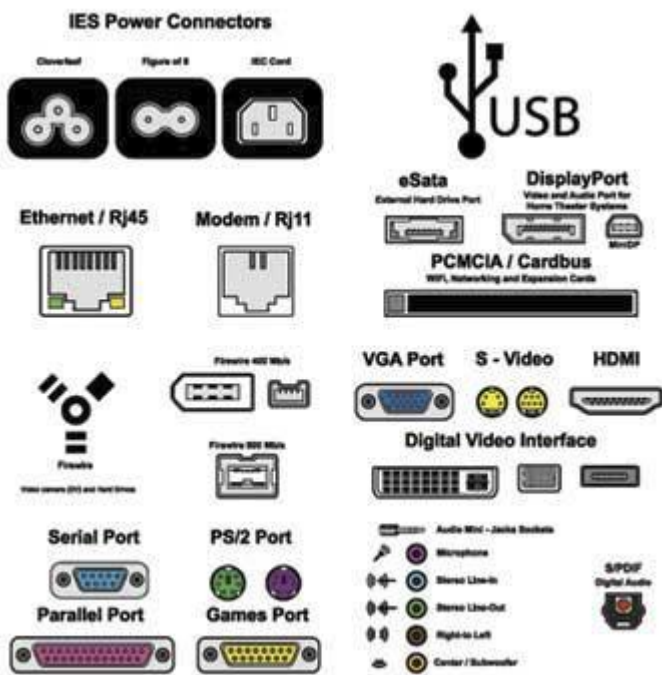
A port:

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

Characteristics

A port has the following characteristics:

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



Following are few important types of ports:

Serial Port

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

Parallel Port

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

PS/2 Port

- Used for old computer keyboard and mouse
 - Also called mouse port
 - Most of the old computers provide two PS/2 port, each for mouse and keyboard
- Also known as IEEE 1284-compliant Centronics port

Universal Serial Bus (or USB) Port

- It can connect all kinds of external USB devices such as external hard disk, printer, scanner, mouse, keyboard etc.
 - It was introduced in 1997.
 - Most of the computers provide two USB ports as minimum.
- Data travels at 12 megabits per seconds
- USB compliant devices can get power from a USB port

VGA Port

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

Power Connector

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

Firewire Port

- Transfers large amount of data at very fast speed.
- Connects camcorders and video equipments to the computer

Data travels at 400 to 800 megabits per seconds

- Invented by Apple
- Three variants : 4-Pin FireWire 400 connector, 6-Pin FireWire 400 connector and 9-Pin FireWire 800 connector

Modem Port

- Connects a PC's modem to the telephone network

Ethernet Port

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

Game Port

- Connect a joystick to a PC
- Now replaced by USB.

Digital Video Interface, DVI port

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

Sockets

- Connect microphone, speakers to sound card of the computer

Computer - 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 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.



Relationship between Hardware and Software

- Hardware and software are mutually dependent on each other. Both of them must work together to make a computer produce a useful output.
- Software cannot be utilized without supporting hardware.
- Hardware without set of programs to operate upon cannot be utilized and is useless.
- To get a particular job done on the computer, relevant software should be loaded into the hardware ·

Hardware is a one-time expense.

- Software development is very expensive and is a continuing expense.
- Different software applications can be loaded on a hardware to run different jobs. ·

A software acts as an interface between the user and the hardware.

- If hardware is the 'heart' of a computer system, then software is its 'soul'. Both are complimentary to each other.

Computer - 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 collection of programs designed to operate, control, and extend the processing capabilities of the computer itself. System software are generally prepared by computer manufactures. These software products comprise of programs written in low-level languages which interact with the hardware at a very basic level. System software serves as the interface between hardware and the end users.

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



Features of system software are as follows:

- Close to system
- Fast in speed
- Difficult to design
- Difficult to understand
- Less interactive
- Smaller in size
- Difficult to manipulate
- Generally written in low-level language

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 a Microsoft's notepad for writing and editing 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 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



Features of application software are as follows:

- Close to user
- Easy to design
- More interactive
- Slow in speed
- Generally written in high-level language
- Easy to understand
- Easy to manipulate and use
- Bigger in size and requires large storage space

Computer - Number System

When we type some letters or words, the computer translates them in numbers as computers can understand only numbers. A computer can understand positional number system where there are only a few symbols called digits and these symbols represent different values depending on the position they occupy in the number.

A value of each digit in a number can be determined using

- The digit
- The position of the digit in the number
- The base of the number system (where base is defined as the total number of digits available in the number system).

Decimal Number System

The number system that we use in our day-to-day life is the decimal number system. Decimal number system has base 10 as it uses 10 digits from 0 to 9. In decimal number system, the successive positions to the left of the decimal point represent units, tens, hundreds, thousands and so on.

Each position represents a specific power of the base (10). For example, the decimal number 1234 consists of the digit 4 in the units position, 3 in the tens position, 2 in the hundreds position, and 1 in the thousands position, and its value can be written as

$$\begin{aligned} &(1 \times 1000) + (2 \times 100) + (3 \times 10) + (4 \times 1) \\ &(1 \times 10^3) + (2 \times 10^2) + (3 \times 10^1) + (4 \times 10^0) \\ &1000 + 200 + 30 + 4 \\ &1234 \end{aligned}$$

As a computer programmer or an IT professional, you should understand the following number systems which are frequently used in computers.

S.N.	Number System and Description
------	-------------------------------

1	Binary Number System
---	-----------------------------

Base 2. Digits used : 0, 1

2	Octal Number System
---	----------------------------

Base 8. Digits used : 0 to 7

3	Hexa Decimal Number System
---	-----------------------------------

Base 16. Digits used : 0 to 9, Letters used : A- F

: Binary Number System

Characteristics of binary number system are as follows:

- Uses two digits, 0 and 1.
- Also called base 2 number system
- Each position in a binary number represents a 0 power of the base (2). Example 2^0
- Last position in a binary number represents a x power of the base (2). Example 2^x where x represents the last position - 1.

Example

Binary Number : 10101_2

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	10101_2	$((1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
Step 2	10101_2	$(16 + 0 + 4 + 0 + 1)_{10}$

Step 3 10101_2 21_{10}

Note : 10101_2 is normally written as 10101.

Octal Number System

Characteristics of octal number system are as follows:

- Uses eight digits, 0,1,2,3,4,5,6,7.
- Also called base 8 number system
- Each position in an octal number represents a 0 power of the base (8). Example 8^0
- Last position in an octal number represents a x power of the base (8). Example 8^x where x represents the last position - 1.

Example

Octal Number : 12570_8

Calculating Decimal Equivalent:

Step	Octal Number	Decimal Number
Step 1	12570_8	$((1 \times 8^4) + (2 \times 8^3) + (5 \times 8^2) + (7 \times 8^1) + (0 \times 8^0))_{10}$
Step 2	12570_8	$(4096 + 1024 + 320 + 56 + 0)_{10}$
Step 3	12570_8	5496_{10}

Note : 12570_8 is normally written as 12570.

Hexadecimal Number System

Characteristics of hexadecimal number system are as follows:

- Uses 10 digits and 6 letters, 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.
 - Letters represents numbers starting from 10. A = 10, B = 11, C = 12, D = 13, E = 14, F = 15.
- Also called base 16 number system
- Each position in a hexadecimal number represents a 0 power of the base (16). Example 16^0
 - Last position in a hexadecimal number represents a x power of the base (16). Example 16^x where x represents the last position - 1.

Example

Hexadecimal Number : $19FDE_{16}$

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	19FDE ₁₆	$((1 \times 16^4) + (9 \times 16^3) + (F \times 16^2) + (D \times 16^1) + (E \times 16^0))_{10}$
Step 2	19FDE ₁₆	$((1 \times 16^4) + (9 \times 16^3) + (15 \times 16^2) + (13 \times 16^1) + (14 \times 16^0))_{10}$
Step 3	19FDE ₁₆	$(65536 + 36864 + 3840 + 208 + 14)_{10}$
Step 4	19FDE ₁₆	106462 ₁₀

Note : 19FDE₁₆ is normally written as 19FDE.

Computer - Number Conversion

There are many methods or techniques which can be used to convert numbers from one base to another. We'll demonstrate here the following:

- Decimal to Other Base System
- Other Base System to Decimal
- Other Base System to Non-Decimal
- Shortcut method - Binary to Octal
- Shortcut method - Octal to Binary
- Shortcut method - Binary to Hexadecimal
- Shortcut method - Hexadecimal to Binary

Decimal to Other Base System

steps

- **Step 1** - Divide the decimal number to be converted by the value of the new base.
- **Step 2** - Get the remainder from Step 1 as the rightmost digit (least significant digit) of new base number.
- **Step 3** - Divide the quotient of the previous divide by the new base.
- **Step 4** - Record the remainder from Step 3 as the next digit (to the left) of the new base number.

Repeat Steps 3 and 4, getting remainders from right to left, until the quotient becomes zero in Step 3.

The last remainder thus obtained will be the most significant digit (MSD) of the new base number.

Example

Decimal Number : 29_{10}

Calculating Binary Equivalent:

Step	Operation	Result	Remainder
Step 1	$29 / 2$	14	1
Step 2	$14 / 2$	7	0
Step 3	$7 / 2$	3	1
Step 4	$3 / 2$	1	1
Step 5	$1 / 2$	0	1

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the least significant digit (LSD) and the last remainder becomes the most significant digit (MSD).

Decimal Number : $29_{10} =$ Binary Number : 11101_2 .

Other base system to Decimal System

Steps

- **Step 1** - Determine the column (positional) value of each digit (this depends on the position of the digit and the base of the number system).
- **Step 2** - Multiply the obtained column values (in Step 1) by the digits in the corresponding columns.
- **Step 3** - Sum the products calculated in Step 2. The total is the equivalent value in decimal.

Example

Binary Number : 11101_2

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	11101_2	$((1 \times 2^4) + (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
Step 2	11101_2	$(16 + 8 + 4 + 0 + 1)_{10}$

Step 3 11101_2 29_{10}

Binary Number : $11101_2 =$ Decimal Number : 29_{10}

Other Base System to Non-Decimal System

Steps

- **Step 1** - Convert the original number to a decimal number (base 10).
- **Step 2** - Convert the decimal number so obtained to the new base number.

Example

Octal Number : 25_8

Calculating Binary Equivalent:

Step 1 : Convert to Decimal

Step	Octal Number	Decimal Number
Step 1	25_8	$((2 \times 8^1) + (5 \times 8^0))_{10}$
Step 2	25_8	$(16 + 5)_{10}$
Step 3	25_8	21_{10}

Octal Number : $25_8 =$ Decimal Number : 21_{10}

Step 2 : Convert Decimal to Binary

Step	Operation	Result	Remainder
Step 1	$21 / 2$	10	1
Step 2	$10 / 2$	5	0
Step 3	$5 / 2$	2	1
Step 4	$2 / 2$	1	0

Step 5 1 / 2 0 1

Decimal Number : $21_{10} =$ Binary Number : 10101_2

Octal Number : $25_8 =$ Binary Number : 10101_2

Shortcut method - Binary to Octal

Steps

- **Step 1** - Divide the binary digits into groups of three (starting from the right).
- **Step 2** - Convert each group of three binary digits to one octal digit.

Example

Binary Number : 10101_2

Calculating Octal Equivalent:

Step Binary Number Octal Number

Step 1 10101_2 010 101

Step 2 10101_2 $2_8 5_8$

Step 3 10101_2 25_8

Binary Number : $10101_2 =$ Octal Number : 25_8

Shortcut method - Octal to Binary

Steps

- **Step 1** - Convert each octal digit to a 3 digit binary number (the octal digits may be treated as decimal for this conversion).
- **Step 2** - Combine all the resulting binary groups (of 3 digits each) into a single binary number.

Example

Octal Number : 25_8

Calculating Binary Equivalent:

Step Octal Number Binary Number

Step 1	25_8	$2_{10}5_{10}$
Step 2	25_8	$010_2 101_2$
Step 3	25_8	010101_2

Octal Number : $25_8 =$ Binary Number : 10101_2

Shortcut method - Binary to Hexadecimal

Steps

- **Step 1** - Divide the binary digits into groups of four (starting from the right).
- **Step 2** - Convert each group of four binary digits to one hexadecimal symbol.

Example

Binary Number : 10101_2

Calculating hexadecimal Equivalent:

Step Binary Number Hexadecimal Number

Step 1	10101_2	$0001 0101$
Step 2	10101_2	$1_{10}5_{10}$
Step 3	10101_2	15_{16}

Binary Number : $10101_2 =$ Hexadecimal Number : 15_{16}

Shortcut method - Hexadecimal to Binary

steps

- **Step 1** - Convert each hexadecimal digit to a 4 digit binary number (the hexadecimal digits may be treated as decimal for this conversion).
- **Step 2** - Combine all the resulting binary groups (of 4 digits each) into a single binary number.

Example

Hexadecimal Number : 15_{16}

Calculating Binary Equivalent:

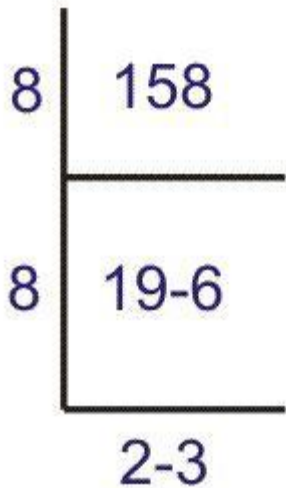
Step Hexadecimal Number Binary Number

Step 1	15_{16}	$1_{10}5_{10}$
Step 2	15_{16}	$0001_2 0101_2$
Step 3	15_{16}	00010101_2

Hexadecimal Number : $15_{16} =$ Binary Number : 10101_2

Decimal to Octal Conversion

This can be done by dividing the number by 8 using repeated division method known as double dabble method. The repeated division is done and the remainder is taken. It can be done as follows- Example Find the octal equivalent of 158.



The equivalent number in octal system is- $(236)_8$. When there is a number in fraction or after the decimal point, that can be converted as- Say we have to convert 0.40 to octal.

- $0.40 \times 8 = 3.20$ ————— — *3 is taken out*
- $0.20 \times 8 = 1.60$ ————— — *1 is taken out*
- $0.60 \times 8 = 4.80$ ————— — *4 is taken out*
- $0.80 \times 8 = 6.40$ ————— — *6 is taken out*

So we see that the number is repeated. This will go on and it will be a never ending process so we can approximate the result as- $(.3146...)_8$.

Advantages of Octal Number Systems

1. It is of one third length of the binary.
2. Easy conversion process from binary to octal and vice-versa.
3. Easier to handle input and output in the octal form.

Disadvantages of Octal Number Systems

Computer does not understand **octal number system** so there must be a requirement of additional circuitry known as octal to binary converters before it is applied to a digital system or a computer.

BCD ,EBCDIC AND ASCII CODE COMPUTER CODE:

- Computer codes are used for internal representation of data in computers
- As computers use binary numbers for internal data representation, computer codes use binary coding schemes
- In binary coding, every symbol that appears in the data is represented by a group of bits
- The group of bits used to represent a symbol is called a **byte**
- As most modern coding schemes use 8 bits to represent a symbol, the term byte is often used to mean a group of 8 bits
 - Commonly used computer codes are BCD, EBCDIC, and ASCII
-

BCD

- BCD stands for **B**inary **C**oded **D**ecimal
- It is one of the early computer codes
- It uses 6 bits to represent a symbol
- It can represent 64 (2^6) different characters

CODING OF ALPHABETIC AND NUMERIC CHARACTERS IN BCD

Char	Zone	Digit	
A	11	0001	61
B	11	0010	62
C	11	0011	63
D	11	0100	64
E	11	0101	65
F	11	0110	66
G	11	0111	67
H	11	1000	70
I	11	1001	71
J	10	0001	41
K	10	0010	42
L	10	0011	43
M	10	0100	44

Char	BCD Code		Octal
	Zone	Digit	
N	10	0101	45
O	10	0110	46
P	10	0111	47
Q	10	1000	50
R	10	1001	51
S	01	0010	22
T	01	0011	23
U	01	0100	24
V	01	0101	25
W	01	0110	26
X	01	0111	27
Y	01	1000	30
Z	01	1001	31

Character	BCD Code		Octal Equivalent
	Zone	Digit	
1	00	0001	01
2	00	0010	02
3	00	0011	03
4	00	0100	04
5	00	0101	05
6	00	0110	06
7	00	0111	07

8	00	1000	10
9	00	1001	11
0	00	1010	12

BCD Coding Scheme (Example 1)

Example

Show the binary digits used to record the word BASE in BCD

Solution:

B = 110010 in BCD binary notation

A = 110001 in BCD binary notation

S = 010010 in BCD binary notation

E = 110101 in BCD binary notation

So the binary digits

<u>110010</u>	<u>110001</u>	<u>010010</u>	<u>110101</u>
B	A	S	E

will record the word BASE in BCD

BCD Coding Scheme (Example 2)

Example

Using octal notation, show BCD coding for the word DIGIT

Solution:

D = 64 in BCD octal notation

I = 71 in BCD octal notation

G = 67 in BCD octal notation

I = 71 in BCD octal notation

T = 23 in BCD octal notation

Hence, BCD coding for the word DIGIT in octal notation will be

<u>64</u>	<u>71</u>	<u>67</u>	<u>71</u>	<u>23</u>
D	I	G	I	T

EBCDIC

- EBCDIC stands for **E**xtended **B**inary **C**oded **D**ecimal **I**nterchange **C**ode
- It uses 8 bits to represent a symbol
- It can represent 256 (2^8) different characters

Coding of Alphabetic and Numeric Characters in EBCDIC

Char	EBCDIC Code		Hex
	Digit	Zone	
A	1100	0001	C1
B	1100	0010	C2
C	1100	0011	C3
D	1100	0100	C4
E	1100	0101	C5
F	1100	0110	C6
G	1100	0111	C7
H	1100	1000	C8
I	1100	1001	C9
J	1101	0001	D1
K	1101	0010	D2
L	1101	0011	D3
M	1101	0100	D4

Char	EBCDIC Code		Hex
	Digit	Zone	
N	1101	0101	D5
O	1101	0110	D6
P	1101	0111	D7
Q	1101	1000	D8
R	1101	1001	D9
S	1110	0010	E2
T	1110	0011	E3
U	1110	0100	E4
V	1110	0101	E5
W	1110	0110	E6
X	1110	0111	E7
Y	1110	1000	E8
Z	1110	1001	E9

	EBCDIC Code		Hexadecima
Character	Digit	Zone	I Equivalent
0	1111	0000	F0
1	1111	0001	F1
2	1111	0010	F2
3	1111	0011	F3
4	1111	0100	F4
5	1111	0101	F5

6	1111	0110	F6
7	1111	0111	F7
8	1111	1000	F8
9	1111	1001	F9

Zoned Decimal Numbers

Zoned decimal numbers are used to represent numeric values (positive, negative, or unsigned) in EBCDIC

A sign indicator (C for plus, D for minus, and F for unsigned) is used in the zone position of the rightmost digit

Zones for all other digits remain as F, the zone value for numeric characters in EBCDIC In zoned format, there is only one digit per byte

Examples Zoned Decimal Numbers

Numeric Value	EBCDIC	Sign Indicator
345	F3F4F5	F for unsigned
+345	F3F4C5	C for positive
-345	F3F4D5	D for negative

Packed Decimal Numbers

Packed decimal numbers are formed from zoned decimal numbers in the following manner:

Step 1: The zone half and the digit half of the rightmost byte are reversed

Step 2: All remaining zones are dropped out

Packed decimal format requires fewer number of bytes than zoned decimal format for representing a number

Numbers represented in packed decimal format can be used for arithmetic operations

Examples of Conversion of Zoned Decimal Numbers to Packed Decimal Format

Numeric Value	EBCDIC	Sign Indicator
345	F3F4F5	345F
+345	F3F4C5	345C
-345	F3F4D5	345D
3456	F3F4F5F6	03456F

EBCDIC Coding Scheme

Example

Using binary notation, write EBCDIC coding for the word BIT. How many bytes are required for this representation?

Solution:

B = 1100 0010 in EBCDIC binary notation

I = 1100 1001 in EBCDIC binary notation

T = 1110 0011 in EBCDIC binary notation

Hence, EBCDIC coding for the word BIT in binary notation will be

<u>11000010</u>	<u>11001001</u>	<u>11100011</u>
B	I	T

3 bytes will be required for this representation because each letter requires 1 byte (or 8 bits)

ASCII

- ASCII stands for **A**merican **S**tandard **C**ode for **I**nformation **I**nterchange.
- ASCII is of two types - ASCII-7 and ASCII-8
- ASCII-7 uses 7 bits to represent a symbol and can represent 128 (2^7) different characters
- ASCII-8 uses 8 bits to represent a symbol and can represent 256 (2^8) different characters

- First 128 characters in ASCII-7 and ASCII-8 are same

Coding of Numeric and Alphabetic Characters in ASCII

Character	ASCII-7 / ASCII-8		Hexadecimal Equivalent
	Zone	Digit	
0	0011	0000	30
1	0011	0001	31
2	0011	0010	32
3	0011	0011	33
4	0011	0100	34
5	0011	0101	35
6	0011	0110	36
7	0011	0111	37
8	0011	1000	38
9	0011	1001	39

Coding of Numeric and Alphabetic Characters in ASCII

Character	ASCII-7 / ASCII-8		Hexadecimal Equivalent
	Zone	Digit	
A	0100	0001	41
B	0100	0010	42
C	0100	0011	43
D	0100	0100	44
E	0100	0101	45
F	0100	0110	46
G	0100	0111	47
H	0100	1000	48
I	0100	1001	49
J	0100	1010	4A
K	0100	1011	4B
L	0100	1100	4C
M	0100	1101	4D

Character	ASCII-7 / ASCII-8		Hexadecimal Equivalent
	Zone	Digit	
N	0100	1110	4E
O	0100	1111	4F
P	0101	0000	50
Q	0101	0001	51
R	0101	0010	52
S	0101	0011	53
T	0101	0100	54
U	0101	0101	55

V	0101	0110	56
W	0101	0111	57
X	0101	1000	58
Y	0101	1001	59
Z	0101	1010	5A

ASCII-7 Coding Scheme

Example

Write binary coding for the word BOY in ASCII-7. How many bytes are required for this representation?

Solution:

B = 1000010 in ASCII-7 binary notation

O = 1001111 in ASCII-7 binary notation

Y = 1011001 in ASCII-7 binary notation

Hence, binary coding for the word BOY in ASCII-7 will be

$$\begin{array}{ccc} \underline{1000010} & \underline{1001111} & \underline{1011001} \\ \text{B} & \text{O} & \text{Y} \end{array}$$

Since each character in ASCII-7 requires one byte for its representation and there are 3 characters in the word BOY, 3 bytes will be required for this representation

ASCII-8 Coding Scheme

Example

Write binary coding for the word SKY in ASCII-8. How many bytes are required for this representation?

Solution:

S = 01010011 in ASCII-8 binary notation

K = 01001011 in ASCII-8 binary notation

Y = 01011001 in ASCII-8 binary notation

Hence, binary coding for the word SKY in ASCII-8 will be

<u>01010011</u>	<u>01001011</u>	<u>01011001</u>
S	K	Y

Since each character in ASCII-8 requires one byte for its representation and there are 3 characters in the word SKY, 3 bytes will be required for this representation

Computer - Data and Information

What is data?

Data can be defined as a representation of facts, concepts or instructions in a formalized manner which should be suitable for communication, interpretation, or processing by human or electronic machine.

Data is represented with the help of characters like alphabets (A-Z,a-z), digits (0-9) or special characters(+,-,/,*,<,>= etc.).

What is Information?

Information is organised or classified data which has some meaningful values for the receiver.

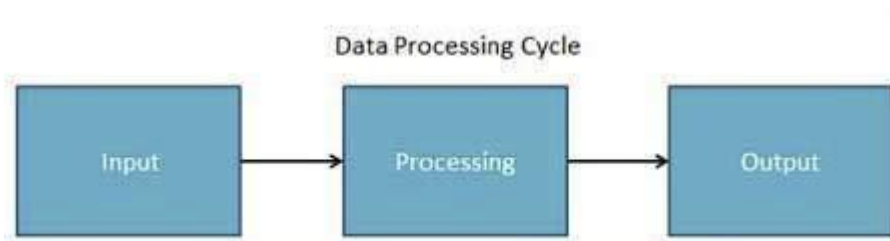
Information is the processed data on which decisions and actions are based.

For the decision to be meaningful, the processed data must qualify for the following characteristics:

- **Timely** - Information should be available when required.
- **Accuracy** - Information should be accurate.
- **Completeness** - Information should be complete.

Data Processing Cycle

Data processing is the re-structuring or re-ordering of data by people or machine to increase their usefulness and add values for particular purpose. Data processing consists of basic steps input, processing and output. These three steps constitute the data processing cycle.



- **Input** - In this step the input data is prepared in some convenient form for processing. The form will depend on the processing machine. For example, when electronic computers are used, the input data could be recorded on any one of several types of input medium, such as magnetic disks, tapes and so on.
- **Processing** - In this step input data is changed to produce data in a more useful form. For example, pay-checks may be calculated from the time cards, or a summary of sales for the month may be calculated from the sales orders.

- **Output** - Here the result of the proceeding processing step are collected. The particular form of the output data depends on the use of the data. For example, output data may be pay-checks for employees.



