# UNIT 1

# Computer Fundamentals

## Chapter 1

# Computer Fundamentals

*After studying this session students will be able to:*

✡ *Learn the evolution of computers*

✡ *Learn about various generations of computer*

✡ *Understand the basic operation of a computer*

✡ *Study the functional components and their interconnections*

✡ *Understand the concept of booting*

✡ *Learn about classification of computers*

## Introduction

Computers are seen everywhere around us, in all spheres of life. May it be the field of education and research, travel and tourism, weather forecasting, social networking, e-commerce or any other, computers have now become an indispensable part of our lives. The manner, in which computers have revolutionised our lives because of their accuracy and speed of performing a job, is truly remarkable. Today no organization can function without a computer. In fact various organizations are trying to become paper free owing to benefits of computers. But the computers of today have evolved over the years from a simple calculating device to the portable high speed computers that we see today.

## Evolution of Computers

The growth of computer industry started with the need for performing fast calculations. The manual method of computing was slow and prone to errors. So attempts were made to develop faster calculating devices. The journey that started from the first calculating device i.e. Abacus has led us today to extremely high speed calculating devices. Let us first have a look at some early calculating devices and then we will explore various generations of computer.

## Abacus

Abacus was discovered by the Mesopotamians in around 3000 BC. An abacus consisted of beads on movable rods divided into two parts. (Fig-1) Addition and multiplication of numbers was done by using the place value of digits of the numbers and position of beads in an abacus.
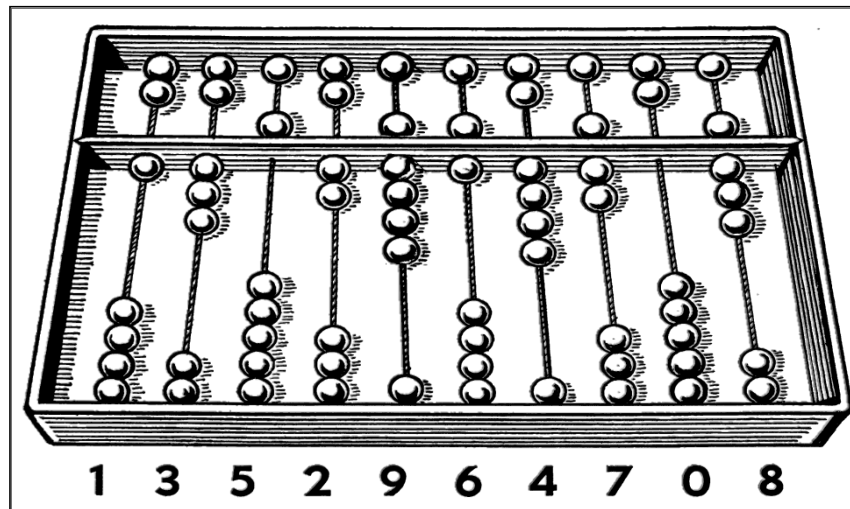


**Fig: An Abacus**

The Chinese further improved on the abacus so that calculations could be done more easily. Even today abacus is considered as an apt tool for young children to do calculations. In an abacus, each row is thought of as a ten's place. From right to left , row no-1 represents the one's column and the second column represents ten's place. The third column represents the hundred's place and so on. The starting position of the top beads (representing the value of five) is always towards the top wall of the abacus while the lower beads (representing the value of one) will always be pushed towards the lower wall as a starting position.

## Napier's Logs and Bones

The idea of logarithm was developed by John Napier in 1617. He devised a set of numbering rods known as Napier's Bones through which both multiplication and division could be performed. These were numbered rods which could perform multiplication of any number by a number in the range of 2-9. There are 10 bones corresponding to the digits 0-9 and there is also a special eleventh bone that is used to represent the multiplier. By placing bones corresponding to the multiplier on the left

side and the bones corresponding to the digits of the multiplicand on the right , the product of two numbers can be easily obtained.



**Fig: Napier's Logs**

### Pascaline

Blaise Pascal, a French mathematician invented an adding machine in 1642 that was made up of gears and was used for adding numbers quickly. This machine was also called Pascaline and was capable of addition and subtraction along with carry-transfer capability. It worked on clock



**Fig: Pascaline**

work mechanism principle. It consisted of various numbered toothed wheels having unique position values. The addition and subtraction operations was performed by controlled rotation of these wheels.

## Leibnitz's Calculator

In 1673 Gottfried Leibnitz, a German mathematician extended the capabilities of the adding machine invented by Pascal to perform multiplication and division as well. The multiplication was done through repeated addition of numbers using a stepped cylinder each with nine teeth of varying lengths.



**Fig: Leibnitz's Calculator**

## Jacquard's Loom

In order to make the cotton weaving process automatic, Joseph Jaquard devised punch cards and used them to control looms in 1801. The entire operation was under a program's control. Through this historic invention, the concept of storing and retrieving information started.

## Difference engine and Analytical Engine

Charles Babbage, an English mathematician developed a machine called Difference Engine in 1822 which could calculate various mathematical functions, do polynomial evaluation by finite difference and theoretically could also solve differential equations.
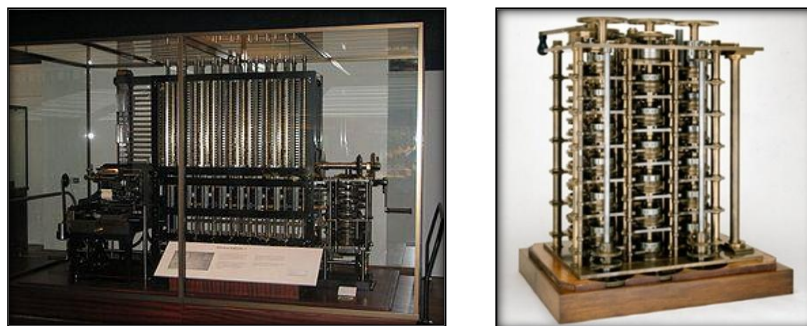


**Fig: Difference Engine and Analytical engine**

Thereafter in 1833, he designed the Analytical Engine which later on proved to be the basis of modern computer. This machine could perform all the four arithmetic operations as well as comparison. It included the concept of central processor, memory storage and input-output devices. Even the stored information could be modified. Although the analytical engine was never built that time but Babbage established the basic principles on which today's modern computers work.

Both these great inventions earned him the title of **'Father of Modern Computers'.**

### Mark 1

In 1944 Prof Howard Aiken in collaboration with IBM constructed an electromechanical computer named Mark 1 which could multiply two 10 digit numbers in 5 seconds. This machine was based on the concept of Babbage's Analytical engine and was the first operational general purpose computer which could execute preprogrammed instructions automatically without any human intervention.
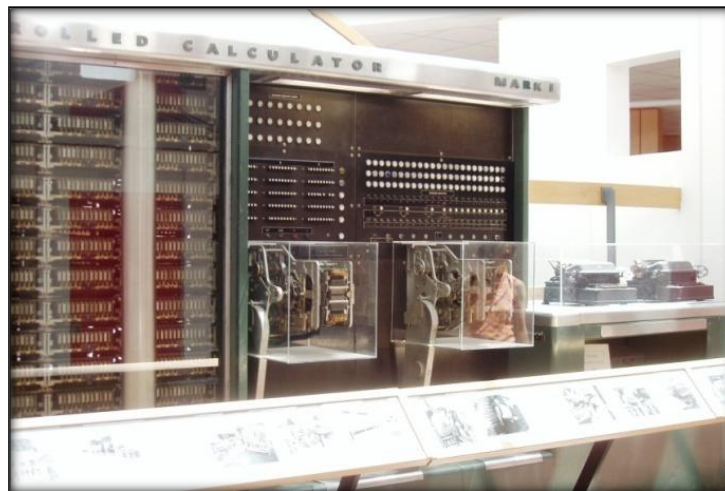


**Fig: Mark 1**

In 1945, Dr. John Von Neumann proposed the concept of a stored program computer. As per this concept the program and data could be stored in the same memory unit. The basic architecture of the Von Neumann computer is shown in the figure below
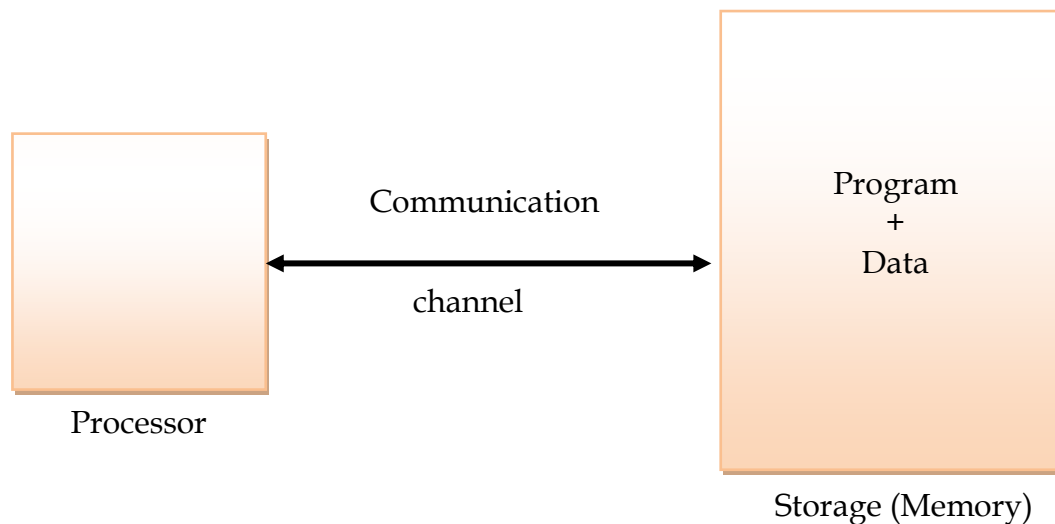
**Fig: Von Neumann Computer**

According to Von Neumann architecture, the processor executes instructions stored in the memory of the computer. Since there is only one communication channel, the processor at a time can either fetch data or an instruction. That means at one point of time either the data or an instruction can be picked (fetched) from the storage unit for execution by the processor. Hence execution takes place in sequential manner. This limitation of Von Neumann Computer is known as Von Neumann bottleneck. EDVAC (**E**lectronic **D**iscrete **V**ariable **A**utomatic **C**omputer) was the first stored program computer developed in 1952. After the invention of first electronic computer ENIAC (**E**lectronic **N**umerical **I**ntegrator and **C**alculator) in 1946, the computer technology improved tremendously and at very fast pace.

## Generation of Computers

Growth in the computer industry is determined by the development in technology. Each phase/generation of computer development is characterized by one or more hardware/software developments that distinctly improved the performance of the computers of that generation. Based on various stages of development, computers can be divided into different generations.

### The First Generation (1942-1955)

The first generation computers used the concept of 'stored program' and were characterized by vacuum tubes. A vacuum tube is a delicate glass device that can control and amplify electronic signals. The first generation computers were made using

thousands of vacuum tubes and were the fastest calculating devices of their time. These computers were very large in size, consumed lot of electricity and generated lot of heat. UNIVAC 1 was the first electronic computer of this generation and was used for business applications.

**Salient features of First generation computers:**

- Used vacuum tubes to control and amplify electronic signals

- Huge computers that occupied lot of space

- High electricity consumption and high heat generation

- Were unreliable since they were prone to frequent hardware failures

- Commercial production was difficult

- They were very costly and required constant maintenance

- Continuous air conditioning was required

- Programming was done in machine language although assembly language also started at the end of this generation Example : ENIAC , EDVAC , UNIVAC 1

**Note:** ENIAC weighed about 27 tons, was of the size 8 feet * 100 feet * 3 feet and consumed around 150 watts of power.

## The Second Generation (1955–1964)

The second generation computers were characterized by transistors. A transistor is a solid state semiconductor device that revolutionized the electronic industry. Transistors were smaller, highly reliable, consumed less electricity and generated less heat. Also magnetic core memories were developed during this generation. These are tiny ferrite rings that can be magnetized in either clockwise or anticlockwise direction so as to represent binary 1 or binary 0. Magnetic cores were used as primary memories. Later magnetic disks also came into existence and were used as secondary storage devices. All these new developments – transistors, magnetic core memory and magnetic disk storage devices made the computers more powerful and reliable. This further led to the existence of operating systems. Programming languages like FORTRAN, COBOL, Algol etc. also developed. Commercial applications of the computer increased and now the computers were used in business and industries for applications like payroll, employee

management, inventory control etc. IBM 1401 and IBM 1620 were popular computers of this generation.

**Salient Features of Second generation computers:**

✿ Use transistor based technology

✿ Were smaller and less expensive as compared to first generation

✿ Consumed less electricity and emitted less heat

✿ Magnetic core memories and magnetic disks were used as primary and secondary storage respectively

✿ First operating system developed

✿ Programming in assembly language and in the later part high level languages were used

✿ Wider commercial use but commercial production was still difficult

✿ They also required constant air-conditioning.

**Examples:** IBM 1401, IBM 1620, UNIVAC 1108

## The Third Generation (1964-1975)

In 1964, the Integrated Circuits or ICs or chips revolutionized the electronic industry and started the third generation of computers. An IC is a small silicon chip or wafer made up of extremely purified silicon crystals. It has numerous transistors, capacitors, resistors and other elements of an electronic circuit. A small scale integration (SSI) chip used to have about 10 transistors on a single chip and a medium scale integration (MSI) chip had about 100 transistors per chip. The size of memories also increased. Various mainframe computers and minicomputers were developed during this generation. Even operating systems with multitasking and multiprogramming features (you will learn about these terms in the next chapter) were developed. Since ICs made the computers highly reliable, relatively inexpensive and faster, computers these days were found in areas of education, small businesses and offices along with industrial and business applications. IBM 360 was a very popular third generation computer.

**Salient Features of Third Generation computers:**

- ✿ Used integrated circuits

- ✿ Computers were smaller , faster and more reliable

- ✿ Low power consumption and less emission of heat as compared to previous generations

**Examples:** IBM 360 series, Honeywell 6000 series

## The Fourth Generation (1975 onwards)

In this generation Large Scale Integration (LSI) and Very Large scale integration (VLSI) technology was used by which up to 300,000 transistors were used on a single chip. Thus integration of complete CPU on a single chip was achieved in 1971 and was named microprocessor which marked the fourth generation of computers. The computers based on microprocessor technology had faster accessing and processing speeds. In addition to this the increased memory capacity further made the computers more powerful and also more efficient operating systems were developed for these computers. New concepts of microprogramming, application software, databases, virtual memory etc were developed and used.

The computers that we use today belong to this generation. These portable computers can be carried from one place to another owing to their compact size. They are much more accurate. Even memory sizes have become phenomenal. Commercial production of these computers is easier and they are the least expensive, compared to the earlier generation computers.

Also computer networks starting coming up during this generation. It is today one of the most popular means to interact and communicate with people.

**Salient features of Fourth generation Computers**

- ✿ ICs with LSI and VLSI technology

- ✿ Microprocessors developed

- ✿ Portable computers developed

- ✿ Networking and data communication  became popular

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- ✿ Different types of secondary memory with high storage capacity and fast access developed

- ✿ Very reliable ,powerful and small in size

- ✿ Negligible power consumption and heat generation

- ✿ Very less production cost

## Fifth Generation Computers

Fifth Generation computers are still under development. This generation is based on the concept of artificial intelligence. In simple terms the computers of this generation are supposed to behave like humans. The principles of parallel processing (many processors are grouped together) and superconductivity are being used to develop devices that respond to human languages and will have the ability to apply previously gained knowledge to execute a task. They will let them make decisions of their own to execute a task. Some applications like voice recognition, visual recognition are a step in this very direction.

**Salient features of fifth generation computers:**

- ✿ Parallel Processing

- ✿ Superconductivity

- ✿ Artificial Intelligence

## Computer - Data and Information

We all know what a computer is? It is an electronic device that processes the input according to the set of instructions provided to it and gives the desired output at a very fast rate. Computers are very versatile as they do lot of different tasks such as storing data, weather forecasting, booking airline, railway or movie tickets and even playing games.

**Data:** It is the term used for raw facts and figures. For example, 134, + 9, 'Raju', 'C' are data. Definition of information should start from next line as given in the word file. In composed file it is starting from the same line immediately after the definition of data. **Information:** Data represented in useful and meaningful form is information. In simple words we can say that data is the raw material that is processed to give meaningful,

ordered or structured information. For example Raju is 9 years old. This is information about Raju and conveys some meaning. This conversion of data to information is called data processing.

## Functional Components of a Computer

The computer is the combination of hardware and software. Hardware are the physical components of a computer like motherboard, memory devices, monitor, keyboard etc. while software is the set of programs or instructions. Both hardware and software together make the computer system function. Let us first have a look at the functional components of a computer.

Every task given to a computer follows an Input- Process- Output Cycle (IPO cycle). It needs certain input, processes that input and produces the desired output. The input unit takes the input, the central processing unit does the processing of data and the output unit produces the output. The memory unit holds the data and instructions during the processing.

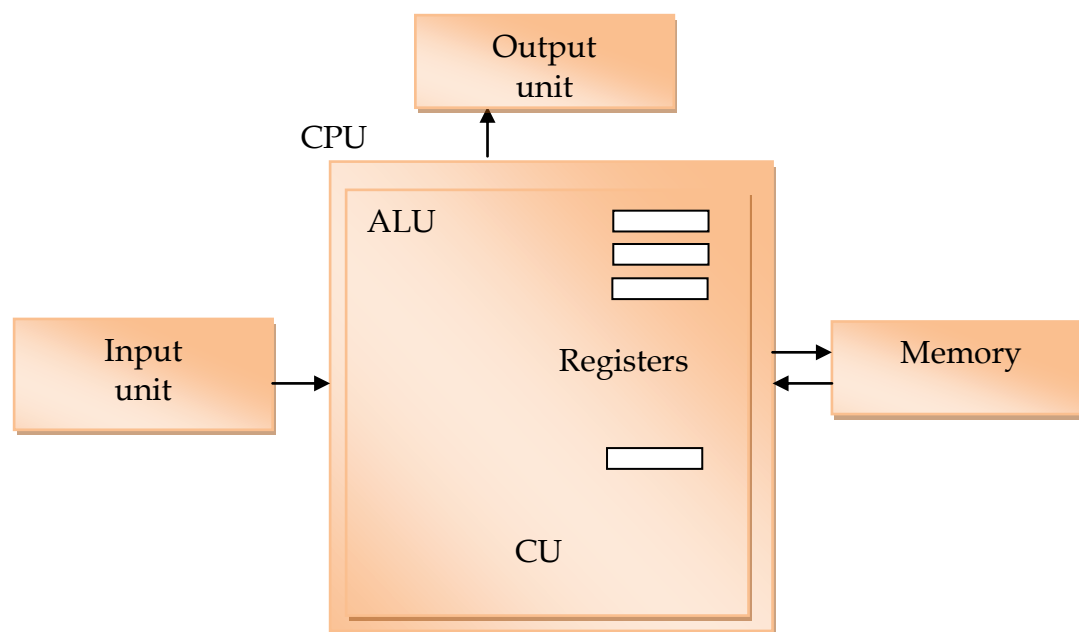Fig below shows the basic structure of the computer.



**Fig: Functional Components of a computer**

### Input Unit

The input unit consists of input devices that are attached to the computer. These devices take input and convert it into binary language that the computer understands. Some of the common input devices are keyboard, mouse, joystick, scanner etc.

### Central Processing Unit (CPU)

Once the information is entered into the computer by the input device, the processor processes it. The CPU is called the brain of the computer because it is the control centre of the computer. As the CPU is located on a small chip, it is also called the microprocessor. It first fetches instructions from memory and then interprets them so as to know what is to be done. If required, data is fetched from memory or input device. Thereafter CPU executes or performs the required computation and then either stores the output or displays on the output device. The CPU has three main components which are responsible for different functions – Arithmetic Logic Unit (ALU) , Control Unit (CU) and  Memory registers.

### Arithmetic and Logic Unit (ALU)

The ALU, as its name suggests performs mathematical calculations and takes logical decisions. Arithmetic calculations include addition, subtraction, multiplication and division. Logical decisions involve comparison of two data items to see which one is larger or smaller or equal.

### Control Unit

The Control unit coordinates and controls the data flow in and out of CPU and also controls all the operations of ALU, memory registers and also input/output units. It is also responsible for carrying out all the instructions stored in the program. It decodes the fetched instruction, interprets (understands) it and sends control signals to input/output devices until the required operation is done properly by ALU and memory.

### Memory Registers

A register is a temporary unit of memory in the CPU. These receive data/information and then this data/information is held in them as per the requirement. Registers can be of different sizes(16 bit , 32 bit , 64 bit and so on) and each register inside the CPU has a

specific function like storing data, storing an instruction, storing address of a location in memory etc. The user registers can be used by an assembly language programmer for storing operands, intermediate results etc. Accumulator (ACC) is the main register in the ALU and contains one of the operands of an operation to be performed in the ALU.

## Memory

Memory attached to the CPU is used for storage of data and instructions and is called internal memory. During processing, it is the internal memory that holds the data. The internal memory is divided into many storage locations, each of which can store data or instructions. Each memory location is of the same size and has an address. With the help of the address, the computer can find any data easily without having to search the entire memory. The internal memory is also called the *Primary memory* or Main memory. When the task is performed, the CU makes the space available for storing data and instructions, thereafter the memory is cleared and the memory space is then available for the next task. The time of access of data is independent of its location in memory, therefore this memory is also called Random Access memory (RAM). Primary memory is volatile in nature. That means when the power is switched off, the data stored in this memory is permanently erased. That is why secondary memory is needed to store data and information permanently for later use. Some of the examples of secondary storage devices are hard disk, compact disks, pen drives etc.

## Output Unit

The output unit consists of output devices that are attached with the computer. It converts the binary data coming from CPU to human understandable from. The common output devices are monitor, printer, plotter etc.

## Interconnection between Functional Components

The interconnection between the functional components of a computer can be done in many ways. In microcomputers we generally see a Common Bus Architecture as shown in the figure below. As we have seen before that a computer consists of input unit that takes input, a CPU that processes the input and an output unit that produces output. All these devices communicate with each other through a common bus. A bus is a transmission path (set of conducting wires) over which data or information in the form

of electric signals, is passed from one component to another in a computer. The bus can be of three types – Address bus, Data bus and Control Bus.
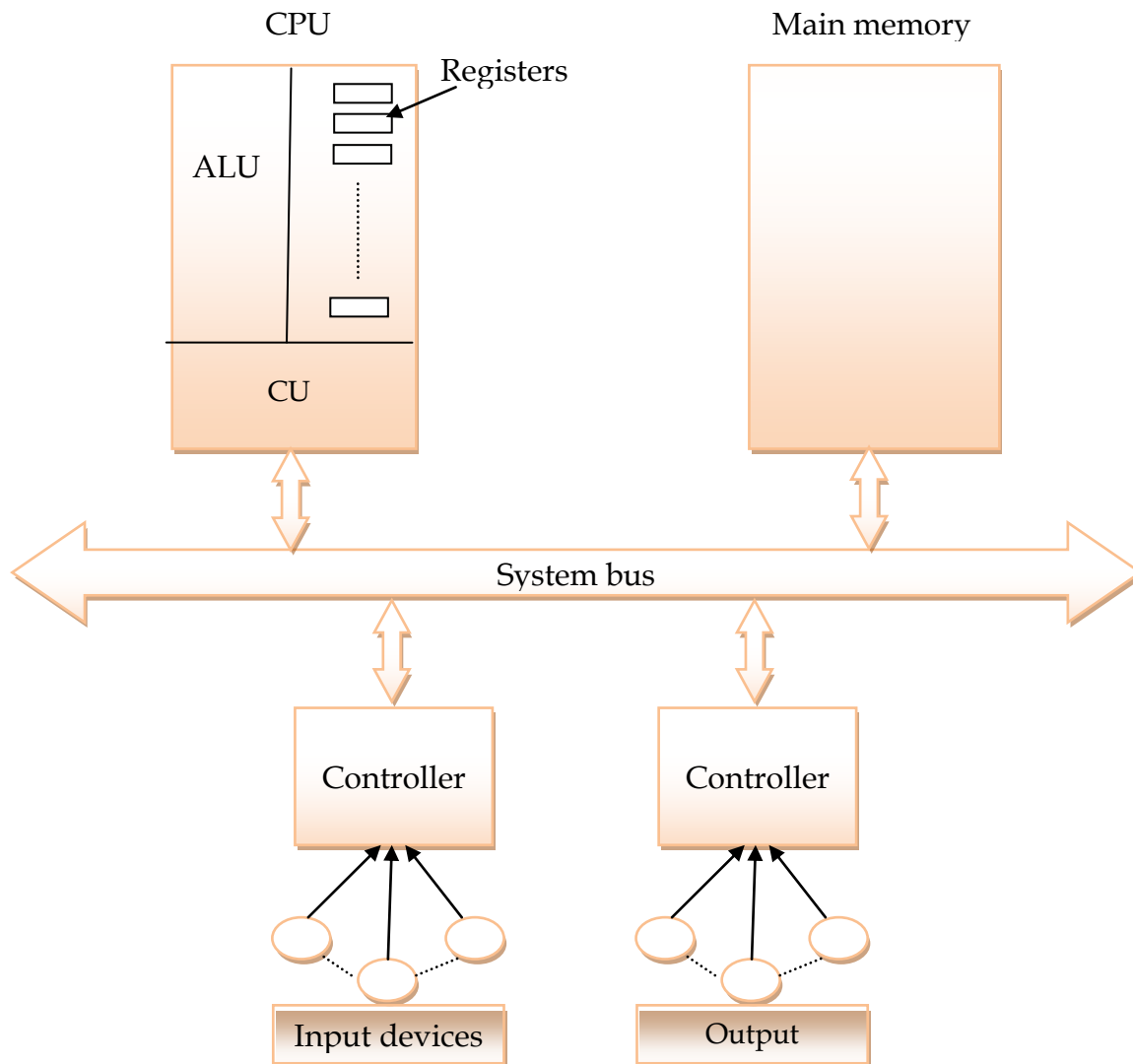


**Fig: Common Bus Architecture**

The address bus carries the address location of the data or instruction. The data bus carries data from one component to another and the control bus carries the control signals. As shown in the figure above, the system bus is the common communication path that carries signals to/from CPU, main memory and input/output devices. The input/output devices communicate with the system bus through the controller circuit. This controller circuit helps to manage various input/output devices attached to the computer.

## Concept of Booting

When the computer is switched on, a copy of boot program is brought from ROM into the main memory. This process is called booting. The CPU first runs a jump instruction that transfers to BIOS (Basic Input output System) and it starts executing. The BIOS conducts a series of self diagnostic tests called POST (Power On Self Test). These tests include memory tests, configuring and starting video circuitry, configuring the system's hardware and checking other devices that help to function the computer properly. Thereafter the BIOS locates a bootable drive to load the boot sector. The execution is then transferred to the Boot Strap Loader program on the boot sector which loads and executes the operating system. If the boot sector is on the hard drive then it will have a Master Boot record (MBR) which checks the partition table for active partition. If found, the MBR loads that partition's boot sector and executes it.

Booting Process is of two types – Warm and Cold

**Cold Booting:** When the system starts from initial state i.e. it is switched on, we call it cold booting or Hard Booting.  When the user presses the Power button, the instructions are read from the ROM to initiate the booting process.

**Warm Booting:** When the system restarts or when Reset button is pressed, we call it Warm Booting or Soft Booting. The system does not start from initial state and so all diagnostic tests need not be carried out in this case. There are chances of data loss and system damage as the data might not have been stored properly.

## Classification of Computers

The computers can be classified based on the technology being used as: Digital, Analog and Hybrid

### Digital Computers

These computers are capable of processing information in discrete form. In digital technology data which can be in the form of letters, symbols or numbers is represented in binary form i.e. 0s and 1s. Binary digits are easily expressed in a digital computer by the presence (1) or absence (0) of current or voltage. It computes by counting and adding operations. The digital computers are used in industrial, business and scientific applications. They are quite suitable for large volume data processing.

### Analog Computers

An analog computer works on continuously changeable aspects of physical phenomenon such as fluid pressure, mechanical motion and electrical quantities. These computers measure changes in continuous physical quantities say current and voltage. These computers are used to process data generated by ongoing physical processes. A thermometer is an example of an analog computer since it measures the change in mercury level continuously. Although the accuracy of an analog computer is less as compared to digital computers, yet it is used to process data generated by changing physical quantities especially when the response to change is fast. Most present day analog computers are well suited to simulating systems. A simulator helps to conduct experiments repeatedly in real time environment. Some of the common examples are simulations in aircrafts, nuclear power plants, hydraulic and electronic networks.

### Hybrid Computers

These use both analog and digital technology. It has the speed of analog computer and the accuracy of a digital computer. It may accept digital or analog signals but an extensive conversion of data from digital to analog and analog to digital has to be done. Generally the analog components provide efficient processing of differential equations while the digital part deals with logical operations of the system. Hence benefits of both analog and digital computing are readily available. Hybrid Computers are used as a cost effective means for complex simulations.

## Classification of Digital Computers

The digital computers are classified according to their computing capabilities. The various types of digital computers are discussed below:

### Micro Computers

These are also known as Personal Computers. These type of digital computer uses a microprocessor (a CPU on a single chip) and include both desktops and laptops. These computers can work on small volume of data, are very versatile and can handle variety of applications. These computers are being used as work stations, CAD, multimedia and advertising applications. Small portable computers such as PDAs (Personal Digital Assistants) and tablets with wireless computing technology are increasingly becoming popular.

### Mini Computers

These computers can support multiple users working simultaneously on the same machine. These are mainly used in an organization where computers installed in various departments are interconnected. These computers are useful for small business organizations.

### Main Frames

These computers are large and very powerful computers with very high memory capacity. These can process huge databases such as census at extremely fast rate. They are suitable for big organizations, banks, industries etc. and can support hundreds of users simultaneously on the network.

### Super Computers

These are fastest and very expensive computers. They can execute billions of instructions per second. These are multiprocessor, parallel systems suitable for specialized complex scientific applications involving huge amounts of mathematical applications such as weather forecasting. The main difference between a supercomputer and a mainframe is that a supercomputer executes fewer programs as fast as possible whereas a mainframe executes many programs concurrently.

## EXERCISE

**Answer the following questions**

a)  Name at least four early calculating devices.

b)  Name the first operational general purpose computer.

c)  Who first proposed the concept of 'Stored Program Computer'?

d)  Define the IPO cycle.

e)  Differentiate between data and information.

f)  Explain the Von Neumann Computer.

g)  Compare the salient features of first and second generation computers.

h)  Why is Charles Babbage known as the Father of Modern Computers?

i)  Explain the functional components of a computer with the help of a block diagram.

j)  What are the functions of the control unit?

k)  Where are the instructions needed to start a computer stored?

l)  Explain booting process and its types.

m)  Differentiate between :

   a)  Digital computers and analog computers.

   b)  Microcomputers and Mini Computers

## Chapter 2

# Software Concepts

*After studying this chapter the student will be able to:*

✿ *Learn different types of Software*

✿ *System Software (Operating system, Language Processors)*

✿ *Utility Software (Antivirus, Compression tools, Backup, Disk Defragmentor)*

✿ *Application Software (General Purpose and Customized)*

✿ *Study the need, functions and types of operating system*

✿ *Study some commonly used operating systems- UNIX, LINUX, Windows, Solaris, BOSS*

✿ *Study mobile operating systems – Android and Symbian*

✿ *Understand Open Source Concepts - Open Source Software, Freeware, Shareware, Proprietary Software.*

## Hardware and Software

A computer consists of both hardware and software and both are equally important for the working of the computer system. The electronic components of a computer system that we can see and touch are called hardware. Software is a general term used for computer programs that control the operations of the computer. A program is a sequence of instructions that perform a particular task. A set of programs form a software. It is the software which gives hardware its capability. Hardware is of no use without software and software cannot be used without hardware.

## Types of Software

**Software can be broadly are categorized as: (Fig 1)**

✿ System Software

✿ Application Software

✿ Utility Software

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                          ┌──────────────┐
                          │   Software   │
                          └──────┬───────┘
        ┌────────────────────────┼────────────────────────┐
 ┌──────────────┐       ┌──────────────┐         ┌──────────────┐
 │    System    │       │   Utility    │         │ Application  │
 │   Software   │       │   Software   │         │   Software   │
 └──────┬───────┘       └──────────────┘         └──────┬───────┘
   ┌────┴─────┐                               ┌──────────┴──────────┐
┌─────────┐ ┌──────────┐              ┌─────────┐      ┌──────────────────┐
│Operating│ │ Language │              │ General │      │Customized Software│
│ System  │ │Translators│             │ Purpose │      └──────────────────┘
└─────────┘ └────┬─────┘              └─────────┘
      ┌──────────┼──────────┐
 ┌─────────┐ ┌─────────┐ ┌───────────┐
 │Compiler │ │Assembler│ │Interpreter│
 └─────────┘ └─────────┘ └───────────┘
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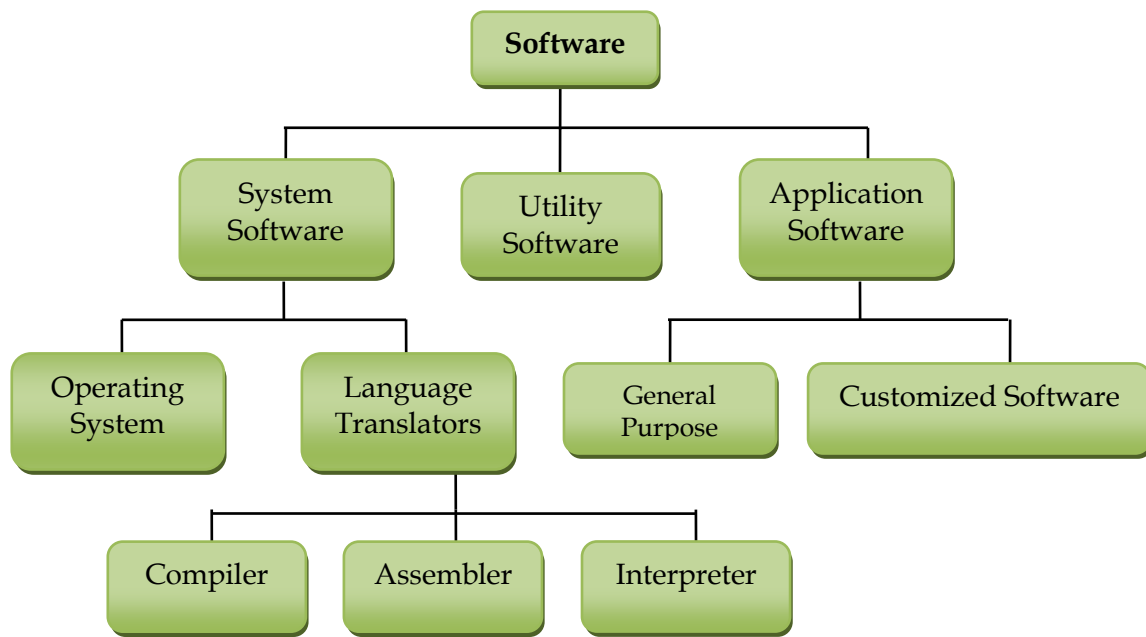
**Fig: Types of Software**

## System Software

System Software is the software that is directly related to coordinating computer operations and performs tasks associated with controlling and utilizing computer hardware. These programs assist in running application programs and are designed to control the operation of a computer system. System software directs the computer what to do, when to do and how to do. System software can be further categorized into

- ✿ Operating System

- ✿ Language Translators

**Operating System**

An Operating system is the most important system software. It is a set of programs that control and supervise the hardware of a computer and also provide services to application software, programmers and users. It manages all hardware and software, input, output and processing activities within the computer system, the flow of information to and from the processor, sets priorities for handling different tasks, and so on. Without operating system a computer cannot do anything useful. When a computer is switched on, the operating system is the first program that is loaded onto

its memory. A user cannot communicate directly with the computer hardware, so the operating system acts as an interface between the user and the computer hardware.

Some of the popular operating systems used in personal computers are DOS, Windows, Unix, Linux, Solaris, etc.

An operating system can be a Single User or a Multiuser operating system. A single user operating system allows only one user to work at any time but a multiuser operating system allows two or more users to use a powerful computer at the same time. For example Windows 7 is a single user operating system while Linux is a multiuser operating system.

**Need for an Operating System**

Operating system provides a platform, on top of which, other programs, called application programs can run. As discussed before, it acts as an interface between the computer and the user. It is designed in such a manner that it operates, controls and executes various applications on the computer. It also allows the computer to manage its own resources such as memory, monitor, keyboard, printer etc.

Our choice of operating system, therefore, depends to a great extent on the CPU and the other attached devices and the applications we want to run. The operating system controls the various system hardware and software resources and allocates them to the users or programs as per their requirement.

**Functions of an Operating System**

An operating system has variety of functions to perform. Some of the prominent functions of an operating system can be broadly outlined as:

✡ **Processor Management:** This deals with management of the Central Processing Unit (CPU). The operating system takes care of the allotment of CPU time to different processes. This is called **scheduling**. Two types of scheduling techniques are employed by an operating system :

- **Priority Scheduling:** Each task is given CPU time according to the priority assigned to that task. The program with higher priority will be given CPU time before a program with lower priority. The CPU executes the task till it is completed or there is some interrupt request i.e. till the time operating

system has to stop (interrupt) the current task due to an unavoidable job request. The major drawback of Priority scheduling is that even a small job has to wait for a long time when a long duration job with higher priority is being executed.

- **Round Robin Scheduling:** This type of scheduling technique is also known as Time Sharing Scheduling. In this, each program or task is given a fixed amount of time to execute. The CPU continues with the execution till either the allotted time is over or there is some interrupt request or the task is completed before the allotted time. If the task is not completed at the end of the allotted time, it is put at the end of the queue. So each task gets its allotted share of CPU time. This scheduling technique improves the response time and provides an interactive environment. Hence time sharing operating system is very useful in network environment as each user is allowed to share the network resources.

✡ **Device Management:** The Operating System communicates with hardware and the attached devices and maintains a balance between them and the CPU. This is all the more important because the CPU processing speed is much higher than that of I/O devices. In order to optimize the CPU time, the operating system employs two techniques - Buffering and Spooling.

- **Buffering:** In this technique the temporary storage of input and output data is done in Input Buffer and Output Buffer. Once the signal for input or output is sent to or from the CPU respectively, the operating system through the device controller moves the data from the input device to the input buffer and for the output device to the output buffer. When the signal is sent to/from the operating system to the respective device controllers, the program doesn't wait rather it returns to its processing. In case of input, if the buffer is full, the operating system sends a signal to the program which processes the data stored in the buffer. When the buffer becomes empty, the program informs the operating system which reloads the buffer and the input operation continues. Similarly for output when the program being executed has to display some output, it fills the buffer and then informs the operating system. Thereafter the operating system empties the buffer by sending data to the output device and in the meantime the program fills

another buffer. This technique is called **overlapped processing**. This is because while the operating system reloads one buffer, the executing program doesn't stop as it is able to retrieve/fill data from/in another buffer.

- **Spooling (Simultaneous Peripheral Operation on Line):** This is a device management technique used for processing of different tasks on the same input/output device. Say for example there are various users on a network sharing the same printer. At one point of time more than one user might give print command. The speed of the printer is very slow as compared to the CPU processing. So the operating system temporarily stores the data of every user on the hard disk of the computer to which the printer is attached. The individual users need not wait for the printing process to be complete. Instead the operating system sends the data from to hard disk to the printer one by one.

✡ **Memory management:** In a computer, both the CPU and the I/O devices interact with the memory. When a program needs to be executed it is loaded onto the main memory till the execution is complete. Thereafter that memory space is freed and is available for other programs. The common memory management techniques used by the operating system are Partitioning and Virtual Memory.

- **Partitioning:** The total memory is divided into various partitions of same size or different sizes. This helps to accommodate number of programs in the memory. The partition can be fixed i.e. remains same for all the programs in the memory or variable i.e. memory is allocated when a program is loaded on to the memory. The later approach causes less wastage of memory but in due course of time, it may become fragmented.

- **Virtual Memory:** This is a technique used by the operating system by virtue of which the user can load the programs which are larger than the main memory of the computer. In this technique the program is executed even if the complete program is not loaded on to the main memory. The operating system divides the main memory into equal sizes called pages. A part of the program resides in the main memory and is called the **active set.** The rest is in the secondary storage device in the form of tracks/sectors or blocks. With

the help of **Page Map Tables (PMT)**, the operating system keeps track which page of main memory is storing which block of secondary memory. A virtual address (which is not the real physical address) is mapped either to the main memory or the secondary memory. Hence virtual memory allows more programs and even larger programs to be executed in the main memory leading to efficient memory utilization.

✿ **File Management:** The operating System manages the files, folders and directory systems on a computer. Any data on a computer is stored in the form of files and the operating system keeps information about all of them using **File Allocation Table (FAT).** The FAT stores general information about files like filename, type (text or binary), size, starting address and access mode (sequential/indexed sequential/direct/relative). The file manager of the operating system helps to create, edit, copy, allocate memory to the files and also updates the FAT. The operating system also takes care that files are opened with proper access rights to read or edit them.

**Types of Operating System**

OS are classified into the following types depending on their capability of processing

✿ **Single User** and **Single Task OS:** It is used on a standalone single computer for performing a single task. Operating systems for Personal Computers (PC) are single-user OS. Single user OS are simple operating system designed to manage one task at a time. MS-DOS is an example of single user OS.

✿ **Multiuser OS** is used in mini computers or mainframes that allow same data and applications to be accessed by multiple users at the same time. The users can also communicate with each other. Linux and UNIX are examples of multiuser OS.

✿ **Multiprocessing OS** have two or more processors for a single running process. Processing takes place in parallel and is also called *parallel processing*. Each processor works on different parts of the same task, or, on two or more different tasks. Since execution takes place in parallel, they are used for high speed execution, and to increase the power of computer. Linux, UNIX and Windows 7 are examples of multiprocessing OS.

✿ **Time sharing Operating System:** It allows execution of more than one tasks or processes concurrently. For this, the processor time is divided amongst different tasks. This division of time is also called **time sharing**. The processor switches rapidly between various processes. After the stipulated time is over, the CPU shifts to next task in waiting, So this type of operating system employs **round robin scheduling technique.** The system switches rapidly from one user to another but still each user feels that it is getting a dedicated CPU time. Virtual Memory techniques are used in this type of operating system. For example, the user can listen to music on the computer while writing an article using a word processing software. The user can switch between the applications and also transfer data between them. Time sharing operating system can be both single user and multiuser. Windows 95 and all later versions of Windows are examples of multitasking OS.

✿ **Real Time Operating System:** It is a multitasking operating system designed for real time applications like robotics. In this type of operating system, the tasks have to be done within a fixed deadline. System performance is good if task is finished within this deadline. If it is not done, the situation is called Deadline Overrun. Lesser the deadline over run, better is the system efficiency. Hence Real Time operating systems depend not only on the logical result of the computation but also on the time in which the results are produced.

✿ **Distributed Operating System:** On a network data is stored and processed on multiple locations. The Distributed Operating System is used on networks as it allows shared data/files to be accessed from any machine on the network in a transparent manner. We can insert and remove the data and can even access all the input and output devices. The users feel as if all data is available on their workstation itself.

✿ **Interactive Operating System:** This is the operating system that provides a Graphic User Interface (GUI) through which the user can easily navigate and interact. The computer responds almost immediately after an instruction has been entered, and the user can enter new instructions after seeing the results of the previous instructions.

**Commonly Used Operating Systems**

Some of the commonly used operating systems are discussed below:

1. **Windows:** Microsoft launched Windows 1.0 operating system in 1985 and since then Windows has ruled the world's software market. It is a GUI (Graphic User Interface) and various versions of Windows have been launched like Windows 95, Windows 98, Win NT, Windows XP, Windows 7 and the latest being Windows 8.

2. **Linux:** Linux is a free and open software which means it is freely available for use and since its source code is also available so anybody can use it, modify it and redistribute it. It can be downloaded from www.linux.org. It is a very popular operating system used and supported by many companies. The defining component of this operating system is the Linux kernel.

3. **BOSS (Bharat Operating System Solutions):** This is an Indian distribution of GNU/Linux. It consists of Linux operating system kernel, office application suite, Bharateeya OO, Internet browser (Firefox), multimedia applications and file sharing.

4. **UNIX:** It is a multitasking, multiuser operating system originally developed in 1969 at Bell Labs. It was one of the first operating systems developed in a high level language, namely C. Due to its portability, flexibility and power, UNIX is widely being used in a networked environment. Today, "UNIX" and "Single UNIX Specification" interface are owned and trademarked by The Open Group. There are many different varieties of UNIX, although they share common similarities, the most popular being GNU/Linux and Mac OS X.

5. **Solaris:** It is a free Unix based operating system introduced by Sun Microsystems in 1992. It is now also known as Oracle Solaris. Solaris is registered as compliant with Single UNIX Specification. It is quite scalable and is used on virtual machines.

**Mobile Operating Systems (Mobile OS)**

It is the operating system that operates on digital mobile devices like smart phones and tablets. It extends the features of a normal operating system for personal computers so as to include touch screen, Bluetooth, WiFi, GPS mobile navigation, camera, music

player and many more. The most commonly used mobile operating systems are – Android and Symbian

**Android:** It is a Linux derived Mobile OS released on 5th November 2007 and by 2011 it had more than 50% of the global Smartphone market share.  It is Google's open and free software that includes an operating system, middleware and some key applications for use on mobile devices. Android applications are quiet user friendly and even one can easily customize the Smartphone with Android OS. Various versions of Android OS have been released like 1.0, 1.5, 1.6, 2. x, 3.0 etc. Most Android phones use the 2.x release while Android 3.0 is available only for tablets. The latest Android version released is 4.2.2. The Android releases have dessert inspired codenames like Cupcake, Honeycomb, Ice Cream sandwich and Jelly Bean.

**Symbian:** This Mobile OS by Nokia (currently being maintained by Accenture) designed for smartphones. It offers high level of functional integration between communication and personal information management. It has an integrated mail box and it completely facilitates the usage of all Google applications in your smartphone easily. Symbian applications are easy to shut down as compared to Android applications. Various versions like S60 series, S80 series, S90 series, Symbian Anna etc have been released. The latest Symbian releases (Symbian Belle) can support 48 languages.

## Language Processors

We know that computer understands instructions in machine code, i.e. in the form of 0s and 1s. It is difficult for us to write computer program directly in machine code. The programs are written mostly in high-level languages, i.e. BASIC, C++, Python etc. A program written in any high-level programming language (or written in assembly language) is called the Source Program or Source Code.

The source code cannot be executed directly by the computer. The source code must be converted into machine language to be executed. The program translated into machine code is known as Object Program or Object code.

The special translator system software that is used to translate the program written in high-level language (or Assembly language) into machine code is called language processor or translator program.

The language processors can be any of the following three types- Assembler, Compiler and Interpreter.

### Assembler

The Assembler is used to translate the program written in Assembly language into machine code. The input of Assembler is a source program that contains assembly language instructions. The output generated by assembler is the object code or machine code understandable by the computer.

### Compiler

The language processor that translates the complete source program as a whole in one go into machine code is called compiler. Some of the examples are C and C++ compilers.

The program translated into machine code is called the object program. The source code is translated to object code successfully if it is free of errors. If there are any errors in the source code, the compiler specifies the errors at the end of compilation with line numbers. The errors must be removed before the compiler can successfully recompile the source code again.

### Interpreter

The language processor that translates a single statement of source program into machine code and executes it immediately before moving on to the next line is called an Interpreter. If there is an error in the statement the interpreter terminates its translating process at that statement and displays an error message.

Only after removal of the error, the interpreter moves on to the next line for execution.

### Utilities

A utility software is one which provides certain tasks that help in proper maintenance of the computer. The job of utility programs is to keep the computer system running smoothly. Nowadays many utility softwares are part of the operating system itself. Even if there is no utility software on your computer, the computer works but with the right kind of utility software loaded, the computer becomes more reliable and even its processing speed increases. Some of the commonly use utility softwares are antivirus, Disk defragmenter, backup, compression etc.

## ✿ Antivirus

An antivirus is utility software which detects and removes computer viruses. If the software is not able to remove the virus, it is neutralized. The antivirus keeps a watch on the functioning of the computer system. If a virus is found it may alert the user, flag the infected program or kill the virus.  Some of the common types of viruses are:

- **Boot Sector Virus:** A boot sector virus displaces the boot record and copies itself to the boot sector i.e. where the program to boot the machine is stored. So first the virus is loaded on to the main memory and then the operating system. Whenever a new disk is inserted the virus copies itself to the new disk. The antivirus overwrites the correct boot record on the infected boot sector and also cleans the bad sectors.

- **File Virus:** A file virus generally attacks executable files.  They can attach to various locations of the original file, replace code, fill in open spaces in the code, or create companion files to work with an executable file.   Most of the file viruses are memory resident and wait in the memory until the user runs another program.  While another program is running, the virus replicates.

- **Macro Virus:** This virus infects an important file called normal.dot of MS Word. As soon as the application is opened the virus gets activated. It damages the formatting of documents and even may not allow editing or saving of documents.

- **Trojan Horse:** It is a code generally hidden in games or spreadsheets. Since they are hidden, the program seems to function as the user wants but actually it is destroying the program. A Trojan horse does not require a host program to embed itself. It is a complete program. Its main objective is to cause harm to the data. They can create bad sectors on the disk, destroy file allocation tables and cause the system to hang.

- **Worm:** Worm is a program capable of replicating itself on a computer network. A worm also does not require a host as it is a self contained program. They generally travel from one computer to another across communication links on a network. They generally disrupt routine services.

### ✿ Disk Defragmenter

The memory is used in small chunks randomly. Sometimes when a memory chunk of appropriate size is not available, the operating system breaks or fragments the files resulting in slower access to files. A disk defragmenter scans the hard disk for fragmented files and brings all the fragments together.

### ✿ Backup Utility

This utility is used to create the copy of the complete or partial data stored in a disk or CD on any other disk. In case the hard disk crashes or some other system failure occurs, the files can be restored using backup software.

### ✿ Compression Utility

This utility is used to compress large files. Compression is useful because it helps reduce resources usage and the file transmission on the network becomes easier.

### ✿ Disk Cleaner

This utility scans for file that have not been accessed/used since long. Such files might be occupying huge amount of memory space. In that case the Disk Cleaner utility prompts the user to delete such files so as to create more space on the disk. If the files are important, the user might take a backup before deleting them.

### ✿ File Management Tools

This utility helps the user in storing, indexing, searching and sorting files and folders on the system. The most commonly used tool is the Windows Explorer and Google Desktop.

## Application Software

An application software is bought by the user to perform specific applications or tasks, say for example making a document or making a presentation or handling inventory or managing the employee database. An application software can be of two types – General Purpose Application Software and Customized Application software.

## General Purpose Application Software

Some of the application software is made for the common users for day to day applications and uses. These are also referred as Office Tools. The users may use them in the manner they want. Some of the popular types of general purpose application software are discussed below:

✿ **Word Processor:** Word processor is a general purpose application software used to create documents. It allows us to create , edit and  format documents.  We can use different types of fonts of various sizes; underline or make bold a certain part of the text. We can add clipart and other graphics into the document. Popular examples of Word processing software are Writer (Open Office) and Microsoft Word.

We use word processing software for various uses like writing a simple document to designing special art effects. Since we can attach images and different shapes, can use different colors, even a poster can be designed using word processing software. Features like Mail Merge, Macro has further enhanced the word processing software and made it very useful.

✿ **Presentation Tools:** Presentation tools is a general purpose application software that lets us create presentations on any topic. We can not only create a presentation and add slides into that but also can use different types of background, fonts, animations, audio, video, etc. We can add clipart and other graphics into our document. Even audio video files can be added on to the presentations. Popular examples of Presentation tools software are Impress (open office) and Microsoft Power Point.

✿ **Spreadsheet Packages:** Spreadsheet is a general purpose application software that lets us create and store data in tabular form.  Both text and numerical values can be entered in that tables known as a spreadsheet. We can not only create a document and add data into that but also can create different types of charts and graphs based upon the numerical data stored in that page. All common mathematical and statistical formulae can be used on the numeric data. Popular examples of Spreadsheet software are Calc (Open Office) and Microsoft Excel.

✿ **Database Management System:** Database Management System is general purpose application software that lets us create computer programs that control the

creation, maintenance, and the use of database for an organization and its end users. We can not only store data but can also manage data in a database. We can also import and export the data to many formats including Excel, Outlook, ASCII, dBase, FoxPro, Oracle, SQL Server, ODBC, etc. Popular examples of Database Management System are Base (Open Office) and Microsoft Access.

## Customized Software

Customized Software is one which is tailor made as per the user's requirement. Such type of software is customer specific. It is made keeping in mind the individual needs of the user and so are also referred as Domain Specific Tools. Such software cannot be installed and used by any other user/customer since the requirements may differ. Some examples of customized software are discussed below:

- ✡ **Inventory Management System & Purchasing System:** Inventory Management System is generally used in departmental stores or other organizations to keep the record of the stock of all the physical resources. For Example, in a Computer store, it keeps record of the number of computers, printers, printing sheet, printer cartridge available. It also helps to place purchase orders, bills, invoices etc. Various reports as to position of stock, sales made in a particular period, profit earned etc. can be generated.

- ✡ **School Management System:** School Management System (sometimes called a School Information System or SIS) is a system that manages all of a school's data in a single, integrated application. Having all of the information in a single system allows schools to more easily connect data together. For example, when viewing a student's record, the user can follow a link to the student's class, and from there a link to the student's teacher, and from there a link to the teacher's other classes, and so on

- ✡ **Payroll System:** Payroll Management System software is used by all modern organizations to keep track of employees of the organization who receives wages or salary. All different payment amounts are calculated by the payroll software and the record is maintained. The software keeps track of personal records of employees viz. name, address, date of birth, qualification, date of joining etc. It also keeps track of professional record viz. allowances, perks, income tax, insurance etc. Different reports, pay slips etc can be generated through this software.

✿ **Financial Accounting:** Financial accounting System is used to prepare accounting information, maintain different accounts ledger, and account books. It also helps an organization to make budget.

✿ **Hotel Management:** Hotel management software refers to management techniques used in the hotel sector. These can include hotel administration, accounts, billing, marketing, housekeeping, front office or front desk, food and beverage management, catering and maintenance. Even advance bookings can be made through this software. Customers can have a look at the hotel and the rooms before making bookings. At any point of time the room availability, tariff for each type of room and even booking status can be checked.

✿ **Reservation System:** Reservation System is software used to book (reserve) air flights, railway seats, movie tickets, tables in a restaurant, etc. In the case of a booking system, the inputs are booking requests. The processing involves checking if bookings are possible, and if so making the bookings. The outputs are booking confirmations/rejections.

✿ **Weather Forecasting system:** This software makes it possible to forecast the weather for days and even months in advance. The detailed weather reports can also be generated.

## Open Source Concepts

Software are mainly categorised into the following categories based on their licenses:

1. Proprietary

2. Shareware

3. Freeware

4. Open source

5. Free Software

### ✿ Proprietary

We pay a supplier for a copy of the software which these days may be supplied on physical media (disks) or downloaded from the Internet. We get the permission to

use the software on one or sometimes more than one machines. Examples of this type of software include Microsoft Office and Microsoft Windows.

## ✡ Shareware

Shareware is basically a software for trial purpose that the user is allowed to try for free, for a specified period of time. It is usually downloaded from the Internet. When the trial period ends, the software must be purchased or uninstalled.

## ✡ Freeware

Freeware software is free of cost and is usually bundled up with some operating system or any other software. Examples of freeware include Microsoft Internet Explorer which comes bundled up with any Microsoft operating system. The author of the freeware software is the owner of the software, though people may use it for free. The source code is not available, so no modifications can be done. Freeware should not be mistaken with Open Source Software or Free Software.

## ✡ Open source

Open Source Software (OSS) is the software which gives the users freedom to run/use the software for any purpose and in any manner. They can be used, modified and even redistributed. In simple terms it can be freely used but it may not be free of charge. The source code is freely available to the customer. Python, Tux Paint etc are examples of Open Source Software.

## ✡ Free Software

This type of software is freely accessible and can be freely used, modified, copied or distributed by anyone. And no licence fee or any other form of payment need to be made for a free software. The source code is also accessible in case of free softwares.

## EXERCISE

**Answer the following questions**

a) 'Hardware is of no use without software and software cannot be used without hardware.' Explain.

b) How can the software be classified? Name at least one software in each of the categories.

c) What is an operating system? Write names of any two popular operating systems.

d) What is the role of a Page Map Table in Virtual Memory Management?

e) Explain the major functions of an operating system.

f) What is the purpose of a language processor?

g) Differentiate between:

    (i) An interpreter and a compiler.

    (ii) Priority Scheduling and Round Robin Scheduling

    (iii) Buffering and SPOOLING

    (iv) Time Sharing and Real Time Operating System

h) Explain any two utilities.

i) What is word processing? Discuss the purpose of word processing software.

j) What is the difference between an Open source Software and a Freeware. Write 2 examples of each.

k) How are Freeware and Free Software different?

## Chapter 3

# Data Representation in Computers

> *After studying this chapter the student will be able to:*
>
> *Learn about binary, octal, decimal and hexadecimal number systems*
>
> *Learn conversions between two different number systems*
>
> *Understand internal storage encoding of characters: ASCII, ISCII and UNICODE*

## Binary Representation of Data

In order to work with data, the data must be represented inside the computer. Digital computers represent data by means of an easily identified symbol called a digit.

## Numbering Systems

Each number system has a base also called a Radix. A decimal number system is a system of base 10; binary is a system of base 2; octal is a system of base 8; and hexadecimal is a system of base 16. What are these varying bases? The answer lies in what happens when we count up to the maximum number that the numbering system allows. In base 10, we can count from 0 to 9, that is,10 digits.

| Number System | Base | Symbols used |
|---|---|---|
| Binary | 2 | 0,1 |
| Octal | 8 | 0,1,2,3,4,5,6,7 |
| Decimal | 10 | 0,1,2,3,4,5,6,7,8,9 |
| Hexadecimal | 16 | 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F where A = 10; B = 11; C = 12; D = 13; E = 14; F = 15 |

Converting a number from one Base to another:

**Binary to Decimal**

Method to convert Binary to Decimal:

1. Start at the rightmost bit.

2. Take that bit and multiply by $2^n$ where n is the current position beginning at 0 and increasing by 1 each time. This represents a power of two.

3. Sum each terms of product until all bits have been used.

**Example**

Convert the Binary number 101011 to its Decimal equivalent.

$1 * 2^5 + 0 * 2^4 + 1 * 2^3 + 0 * 2^2 + 1 * 2^1 + 1 * 2^0$

$32 + 0 + 8 + 0 + 2 + 1 = (43)_{10}$

**Example**

Convert the Binary number 1001 to its Decimal equivalent.

$1 * 2^3 + 0 * 2^2 + 0 * 2^1 + 1 * 2^0$

$8 + 0 + 0 + 1 = (9)_{10}$

**Binary fraction to decimal**

**Example**

Convert $(11011.101)_2$ to decimal

| $2^4$ | $2^3$ | $2^2$ | $2^1$ | . | $2^0$ | $2^{-1}$ | $2^{-2}$ | $2^{-3}$ |
|-----|-----|-----|-----|---|-----|------|------|------|
| 1 | 1 | 0 | 1 | | 1 | 1 | 0 | 1 |

$= (1 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) + (1 \times 2^{-1}) + (0 \times 2^{-2}) + (1 \times 2^{-3})$

$= 16 + 8 + 0 + 2 + 1 + 0.5 + 0 + 0.125$

$= (27.625)_{10}$

**Decimal to Binary**

Method to convert a Decimal number into its Binary equivalent:

1. Divide the decimal number by 2.

2. Take the remainder and record it on the side.

3. Divide the quotient by 2.

4. REPEAT UNTIL the decimal number cannot be divided further.

5. Record the remainders in reverse order and you get the resultant binary number.

**Example**

Convert the Decimal number 125 into its Binary equivalent.

| | |
|---|---|
| 125 / 2 = 62 | 1 |
| 62 / 2 = 31 | 0 |
| 31 / 2 = 15 | 1 |
| 15 / 2 = 7 | 1 |
| 7 / 2 = 3 | 1 |
| 3 / 2 = 1 | 1 |
| 1 / 2 = 0 | 1 |

**Answer: $(1111101)_2$**

**Converting Decimal fraction to Binary**

**Example**

Convert $(0.75)_{10}$ to binary

Multiply the given fraction by 2. Keep the integer in the product as it is and multiply the new fraction in the product by 2. Continue the process till the required number of decimal places or till you get zero in the fraction part. Record the integers in the products from top to bottom.

| | |
|---|---|
| Given fraction | 0.75 |
| Multiply 0.75 by 2 | 1.50 |
| Multiply 0.50 by 2 | 1.00 |

Reading the integers from top to bottom 0.75 in decimal number system is 0.11 in binary number system.

**Example**

Convert $(105.15)_{10}$ to binary

Let us convert 105 first.

$(105)_{10}$ = $(1101001)_2$

Let us convert $(0.15)_{10}$

| | |
|---|---|
| Multiply 0.15 by 2 | 0.30 |
| Multiply 0.30 by 2 | 0.60 |
| Multiply 0.60 by 2 | 1.20 |
| Multiply 0.20 by 2 | 0.40 |
| Multiply 0.40 by 2 | 0.80 |
| Multiply 0.80 by 2 | 1.60 |

Reading the integers from top to bottom $(0.15)_{10}$ = $(0.001001)_2$

Final result $(105.15)_{10}$ = $(1101001.001001)_2$

**Decimal to Octal**

The method to convert a decimal number into its octal equivalent:

1.    Divide the decimal number by 8.

2.    Take the remainder and record it on the side.

3.    Divide the quotient by 8.

4.    REPEAT UNTIL the decimal number cannot be divided further.

5.    Record the remainders in reverse order and you get the resultant binary

**Example**

Convert the Decimal number 125 into its Octal equivalent.

| | |
|---|---|
| 125 / 8 = 15 | 5 |
| 15/ 8 = 1 | 7 |
| 1/8 =0 | 1 |

**Answer: $(175)_8$**

**Converting Decimal fraction to Octal**

**Example**

Convert $(0.75)_{10}$ to Octal

Multiply the given fraction by 8. Keep the integer in the product as it is and multiply the new fraction in the product by 8. Continue the process and read the integers in the products from top to bottom.

| | |
|---|---|
| Given fraction | 0.75 |
| Multiply 0.75 by 8 | 6.00 |

Reading the integers from top to bottom 0.75 in decimal number system is 0.6 in octal number system.

**Octal to Decimal**

Method to convert Octal to Decimal:

1.  Start at the rightmost bit.

2 .  Take that bit and multiply by $8^n$ where n is the current position beginning at 0 and increasing by 1 each time.  This represents the power of 8.

3.  Sum each of the product terms until all bits have been used.

**Example**

Convert the Octal number 321 to its Decimal  equivalent.

$3 * 8^2 + 2 * 8^1 + 1 * 8^0$

$192+16+ 1 = (209)_{10}$

**Octal fraction to decimal**

**Example**

Convert $(23.25)_8$ to decimal

| $8^1$ | $8^0$ | . | $8^{-1}$ | $8^{-2}$ |
|---|---|---|---|---|
| 2 | 3 | | 2 | 5 |

$= (2 \times 8^1) + (3 \times 8^0) + (2 \times 8^{-1}) + (5 \times 8^{-2})$

$= 16+3+0.25+0.07812$

$= (19.32812)_{10}$

## Decimal to Hexadecimal

Method to convert a Decimal number into its Hexadecimal equivalent:

1. Divide the decimal number by 16.

2. Take the remainder and record it on the side.

3. REPEAT UNTIL the decimal number cannot be divided further.

4. Record the remainders in reverse order and you get the equivalent hexadecimal number.

## Example

Convert the Decimal number 300 into its hexadecimal equivalent.

| | |
|---|---|
| 300 / 16 = 18 | 12-(C) |
| 18 / 16 = 1 | 2 |
| 1 / 16 = 0 | 1 |

**Answer: $(12C)_{16}$**

## Converting Decimal fraction to Hexadecimal

## Example

Convert $(0.75)_{10}$ to hexadecimal

Multiply the given fraction by 16. Keep the integer in the product as it is and multiply the new fraction in the product by 16. Continue the process and read the integers in the products from top to bottom.

| | |
|---|---|
| Given fraction | 0.75 |
| Multiply 0.75 by 16 | 12.00  - C |

Reading the integers from top to bottom 0.75 in decimal number system is 0C in Hexadecimal number system.

### Hexadecimal to Decimal

Method to convert Hexadecimal to Decimal:

1. Start at the rightmost bit.

2. Take that bit and multiply by $16^n$ where n is the current position beginning at 0 and increasing by 1 each time. This represents a power of 16.

3. Sum each terms of product until all bits have been used.

### Example

Convert the Hexadecimal number AB to its Decimal equivalent.

$$= A * 16^1 + B * 16^0$$

$$= 10 * 16^1 + 11 * 16^0$$

$$= 160 + 11 = (171)_{16}$$

### Hexadecimal fraction to decimal

### Example

Convert $(1E.8C)_{16}$ to decimal

| $16^1$ | $16^0$ | . | $16^{-1}$ | $16^{-2}$ |
|--------|--------|---|-----------|-----------|
| 1 | E | | 8 | C |

$$= (1 \times 16^1) + (14 \times 16^0) + (8 \times 16^{-1}) + (12 \times 16^{-2})$$

$$= 16 + 14 + 0.5 + 0.04688$$

$$= (30.54688)_{10}$$

### Binary to Hexadecimal

The hexadecimal number system uses the digits 0 to 9 and A, B, C, D, E, F.

**Method to convert a Binary number to its Hexadecimal equivalent is:**

We take a binary number in groups of 4 and use the appropriate hexadecimal digit in it's place. We begin at the rightmost 4 bits. If we are not able to form a group of four, insert 0s to the left until we get all groups of 4 bits each. Write the hexadecimal equivalent of each group. Repeat the steps until all groups have been converted.

**Example**

Convert the binary number 1000101 to its Hexadecimal equivalent.

**0**100    0101        Note that we needed to insert a 0 to the left of 100.

4        5

**Answer: $(45)_{16}$**

In case of a fractional binary number form groups of four bits on each side of decimal point. Then replace each group by its corresponding hexadecimal number.

**Example**

Convert $(11100.1010)_2$ to hexadecimal equivalent.

⟵————    ————⟶

0001 1100    .    1010

1    C    .    A

**Answer : $(1C.A)_{16}$**

**Hexadecimal to Binary**

**Method to convert a Hexadecimal number to its Binary equivalent is:**

Convert each digit of Hexadecimal Number to it's binary equivalent and write them in 4 bits. Then, combine each 4 bit binary number and that is the resulting answer.

**Example**

Convert the Hexadecimal number $(10AF)_{16}$ to its Binary equivalent.

1    0    A    F

0001 | 0000 | 1010 | 1111

**Answer: $(0001000010101111)_2$**

**Example**

Convert the Hexadecimal number $(A2F)_{16}$ to its Binary equivalent.

A    2    F

1010 | 0010 | 1111

**Answer: $(1010\ 0010\ 1111)_2$**

### Binary to Octal and Octal to Binary

To convert Binary to Octal, as the octal system is a power of two ($2^3$), we can take the bits into groups of 3 and represent each group as an octal digit. The steps are the same for the binary to hexadecimal conversions except we are dealing with the octal base now.

To convert from octal to binary, we simply represent each octal digit in it's three bit binary form.

### Example

Convert the Octal number $(742)_8$ to its Binary equivalent.

    7  |   4  |   2

    111 | 100 | 010

**Answer: $(111100010)_2$**

### Hexadecimal to Octal and Octal to Hexadecimal

To convert Hexadecimal to Octal, Convert each digit of Hexadecimal Number to it's binary equivalent and write them in 4 bits. Then, combine each 3 bit binary number and that is converted into octal.

### Example

Convert the Hexadecimal number $(A42)_{16}$ to its Octal equivalent.

    A | 4 | 2

    1010 | 0100 | 0010

    101 | 001 | 000 | 010

**Answer: $(5102)_8$**

To convert Octal to hexadecimal, convert each digit of Octal Number to it's binary equivalent and write them in 3 bits. Then, combine each 4 bit binary number and that is converted into hexadecimal.

### Example

Convert the Octal number $(762)_8$ to its hexadecimal equivalent.

7 | 6 | 2

101 | 110 | 010

0001 | 0111 | 0010

**Answer: (172)$_{16}$**

The following table summarizes the number representation in decimal, binary, octal and hexadecimal number system:

| Decimal | Binary | Octal | Hexadecimal |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 |
| 2 | 10 | 2 | 2 |
| 3 | 11 | 3 | 3 |
| 4 | 100 | 4 | 4 |
| 5 | 101 | 5 | 5 |
| 6 | 110 | 6 | 6 |
| 7 | 111 | 7 | 7 |
| 8 | 1000 | 10 | 8 |
| 9 | 1001 | 11 | 9 |
| 10 | 1010 | 12 | A |
| 11 | 1011 | 13 | B |
| 12 | 1100 | 14 | C |
| 13 | 1101 | 15 | D |
| 14 | 1110 | 16 | E |
| 15 | 1111 | 17 | F |

**Fig: Number Representation**

## Binary Representation of Integers

Binary number can be represented only by using 0's and 1's, but can not use the sign (-) to denote the negative number or sign (+) to denote the positive number. So it must be either 0 or 1. There are three methods to represent binary number. They are

(i)   Sign and magnitude method

(ii)  One's complement method

(iii) Two's complement method

### Sign and magnitude method

In this method, first bit is considered as a sign bit. Here positive number starts with 0 and negative number starts with 1.

**Example**

$$25$$

| | |
|---|---|
| 25/2 = 12 | 1 |
| 12/2 = 6 | 0 |
| 6/2 = 3 | 0 |
| 3/2 = 1 | 1 |
| 1/2 = 0 | 1 |

So the binary number is $(11001)_2$. If we take the size of the word is 1 byte, then the number 25 will be represented as

    00011001

Suppose, if the number is -25, and then it will be represented as

    10011001

### One's Complement Method

In this method, the positive number is represented as same as the binary number. If the number is negative, then we need to find one's complement of a binary number. The one's complement of a binary number will replace every 0 with 1 and vice- versa.

**Example**

(i)   Represent 86 in one's complement method (I byte representation)

> 86/2  =43      0
>
> 43/2  =21      1
>
> 21/2  =10      1
>
> 10/2  =5       0
>
> 5/2   =2       1
>
> 2/2   =1       0
>
> 1/2   =0       1

The binary number is 1010110

1 byte representation of number 86 is 01010110

(ii)  Represent -55 in one's complement method (I byte representation)

> 55/2  =27      1
>
> 27/2  =13      1
>
> 13/2  =6       1
>
> 6/2   =3       0
>
> 3/2   =1       1
>
> 1/2   =0       1

The binary number is 110111

1 byte representation is 00110111

The given number is negative; hence we need to calculate one's complement

One's complement of 00110111 is 11001000 (convert 1 into 0 and 0 into 1)

Thus, the 1 byte representation of number -55 is 11001000.

## Two's Complement method

In this method, the positive number is represented as the binary number. If the number is negative, then we need to calculate two's complement of a binary number. The two's complement of a binary number is calculated by adding 1 to its one's complement.

**Example**

(i)     Represent 87 in two's complement method (I byte representation)

        87/2   =43       1

        43/2   =21       1

        21/2   =10       1

        10/2   =5        0

        5/2     =2        1

        2/2     =1        0

        1/2     =0        1

The binary number is 1010111

Hence, the 1 byte representation of number 86 is 01010111

(ii)    Represent -54 two's complement method (I byte representation)

        54/2   =27       0

        27/2   =13       1

        13/2   =6        1

        6/2     =3        0

        3/2     =1        1

        1/2     =0        1

The binary number is 110110

Hence, the 1 byte representation is  00110110

The given number is negative; hence we need to calculate two's complement.

One's complement of 00110110 is 11001001 (convert 1 into 0 and 0 into 1)

Add 1 to one's complement

$$1$$

11001001      (1+1=2, binary equivalent =11)

$$\underline{+\ 1}$$

11001010

Thus, 1 byte representation of number -54 is 11001010

(iii) Represent -77 two's complement method (I byte representation)

77/2  =38     1

38/2  =19     0

19/2  =9      1

9/2   =4      1

4/2   =2      0

2/2   =1      0

1/2   =0      1

The binary number is 1001101

Hence, 1 byte representation is  01001101.

Since the given number is negative, we need to calculate two's complement.

One's complement of 01001101 is 10110010

10110010

$$\underline{+\ 1}$$

10110011

Thus, 1 byte representation of number -77 is 10110011

## Representing Characters

A computer can handle numeric and non numeric data like letters, punctuation marks and other special characters. Some predefined codes are used to represent numeric and non numeric characters. Some of the standards are discussed below:

## ASCII

ASCII stands for American Standard Code for Information Interchange. ASCII-7 can represent 128 characters. Out of 7 bits, 3 are zone bits and 4 are numeric bits. ASCII-8 can represent 256 characters. It is an extended form of ASCII-7.

| Character | ASCII-7 | Code | ASCII-8 | Code |
|:---:|:---:|:---:|:---:|:---:|
| | Zone | Digit | Zone | Digit |
| 0 | 011 | 0000 | 0101 | 0000 |
| 1 | 011 | 0004 | 0101 | 0001 |
| 2 | 011 | 0010 | 0101 | 0010 |
| 3 | 011 | 0011 | 0101 | 0011 |
| 4 | 011 | 0100 | 0101 | 0100 |
| 5 | 011 | 0101 | 0101 | 0101 |
| 6 | 011 | 0110 | 0101 | 0110 |
| 7 | 011 | 0111 | 0101 | 0111 |
| 8 | 011 | 1000 | 0101 | 1000 |
| 9 | 011 | 1000 | 0101 | 1001 |
| A | 100 | 0001 | 1010 | 0001 |
| B | 100 | 0010 | 1010 | 0010 |
| C | 100 | 0011 | 1010 | 0011 |
| D | 100 | 0100 | 1010 | 0100 |
| E | 100 | 0101 | 1010 | 0101 |
| F | 100 | 0110 | 1010 | 0110 |
| G | 200 | 0111 | 1010 | 0111 |
| H | 100 | 1000 | 1010 | 1000 |
| I | 100 | 1001 | 1010 | 1001 |
| J | 100 | 1010 | 1010 | 1010 |
| K | 100 | 1011 | 1010 | 1011 |

| | | | | |
|---|---|---|---|---|
| L | 100 | 1100 | 1010 | 1100 |
| M | 100 | 1101 | 1010 | 1101 |
| N | 100 | 1110 | 1010 | 1110 |
| O | 100 | 1111 | 1010 | 1111 |
| P | 101 | 0000 | 1011 | 0000 |
| Q | 101 | 0001 | 1011 | 0000 |
| R | 101 | 0010 | 1011 | 0010 |
| S | 101 | 0011 | 1011 | 0011 |
| T | 101 | 0100 | 1011 | 0100 |
| U | 101 | 0101 | 1011 | 0101 |
| V | 101 | 0110 | 1011 | 0110 |
| W | 101 | 0111 | 1011 | 0111 |
| X | 101 | 1000 | 1011 | 1000 |
| Y | 101 | 1001 | 1011 | 1001 |
| Z | 101 | 1010 | 1011 | 1010 |

### ISCII: (Indian Standard Code for Information Interchange)

A lot of efforts have gone into facilitating the use of Indian languages on computers. In 1991, the Bureau of Indian Standards adopted the ISCII. It is an 8 bit code which allows English and Indian Scripts alphabets to be used simultaneously. Characters coded in ISCII need 8 bits for each character.

### Unicode

Unicode is a new universal coding standard adopted by all new platforms. It is promoted by Unicode Consortium which is a non profit organization. Unicode provides a unique number for every character irrespective of the platform, program and the language. It is a character coding system designed to support the worldwide interchange, processing, and display of the written texts of the diverse languages.

## EXERCISE

a) What does ASCII stand for?

b) What does the base of a Number system mean?

c) What is the base of Decimal, Binary, Octal and Hexadecimal number systems?

d) How many digits are there in a Binary number system?

e) Which digits are used in Hexadecimal number system?

f) What is Unicode? How is it useful?

g) Distinguish between ASCII and ISCII.

h) Do as directed :

   ✿ Convert the Decimal number 781 to its Binary equivalent.

   ✿ Convert Binary number 101101.001 to its decimal equivalent

   ✿ Convert Octal number 321.7 into its Binary equivalent

   ✿ Convert the Hexadecimal number 3BC into its Binary equivalent

   ✿ Convert the Binary number 10011010.010101 to its Hexadecimal equivalent

   ✿ Convert the Decimal number 345 into Octal number.

   ✿ Convert the Decimal number 736 into Hexadecimal number.

   ✿ Convert the Octal number 246.45 into Hexadecimal number.

   ✿ Convert the Hexadecimal number ABF.C into Octal number.

   ✿ Convert the Octal number 576 to Decimal.

   ✿ Convert the Hexadecimal number A5C1 to Decimal.

**Chapter 4**

# Microprocessors and Memory Concepts

*After studying this session students will be able to:*

*\*Learn about a microprocessor and its characteristics*

*\*Classify the microprocessors – RISC, CISC and EPIC*

*\*Learn the various units of memory*

*\*Understand the memory types- Primary memory and Secondary memory*

*\*Learn about various input- output ports /connections*

## Microprocessor

We studied that the Central processing unit processes data inside the computer. It interprets all the instructions given to it and carries out these instructions. A microprocessor is a Central Processing Unit (CPU) on a single chip. It is a multipurpose programmable device constructed using Metal Oxide Semiconductor (MOS) technology. In 1971 Intel Corporation fabricated the first microprocessor- 4004. It could do only add and subtract operations and that too it could process only 4 bits at a time. But Intel 4004 powered one of the first portable electronic calculators and since then the microprocessor technology has come a long way. Today we have processors with which can process upto 128 bits at a time at the speed of billion instructions per second.

Let us now have a look at the characteristics of microprocessors:

✡ **Instruction Set:** It is the set of instructions that the microprocessor executes

✡ **Word Length:** The number of bits processed in a single instruction is called word length or word size. The word size is directly proportional to the processing power of the CPU. During the processing, the internal general purpose registers hold data. So if internal registers can hold data upto 8 bits, the word length is 8 bits. If it can process 16 bits at a time, then the internal registers can hold upto 16 bits at a time and so on. Hence a 32 bit processor is about 4 times faster than an 8 bit processor. Examples of word lengths are 16 bit, 32 bit, 64 bit. The terms 16-bit CPU, 32-bit CPU, 64-bit CPU are used very often while talking about CPUs. Now

we know that these terms mean the maximum number of bits a given CPU can handle at a time.

- ✡ **System Clock Speed:** The microprocessor's pace is controlled by the System Clock. The System Clock is an electronic circuit that generates pulses which are measured in million of cycles per second (MHz). The number of pulses generated by the clock per unit of time is its Clock speed. Each microprocessor is characterized by its clock speed. Nowadays microprocessors have clock speed of several GHz. The CPU uses this clock speed to control sequencing and execution of various operations in the computer.

## Classification of Microprocessors

Apart from the width of data (word length) that the microprocessors can process at a time, the classification is also based on the architecture i.e. Instruction Set of the microprocessor. While studying about CPUs, we come across two abbreviations CISC and RISC.

- ✡ **RISC:** It stands for Reduced Instruction Set Computer. It is a type of microprocessor architecture that uses a small set of instructions of uniform length. These are simple but primitive instructions which execute in one clock cycle. For this reason, RISC chips are less complex and also less expensive to produce. The instructions are of uniform length which interface with about 32-36 registers. The program size in case of RISC architecture is more but more memory cycles are needed to access data. To reduce the number of memory cycles, RISC keeps the necessary data in the processor itself. The drawback of RISC design is that the computer must combine or repeat operations to complete a large program consisting of many processing operations. Since instructions are simple , RISC processors are relatively simple to design. Examples of RISC processor is SPARC, POWER PC etc.

- ✡ **CISC:** It stands for Complex Instruction Set Computer. A CISC chip such as Intel Pentium provides programmers with hundreds of instructions of variable sizes, and the processing circuitry includes many special purpose circuits that carry out these instructions at high speeds. These instructions interface with memory in multiple mechanisms with complex addressing modes. In this case the program size is reduced and hence lesser number of memory cycles are required to execute

the instruction. So fewer general purpose registers(8-12) are present in CISC processors. Also less number of memory cycles result in faster execution of the program.

✦ **EPIC:** It stands for Explicitly Parallel Instruction Computing. It is a computer architecture that combines the best feature of both RISC and CISC. It does not use instructions of any fixed length but rather aims at parallel processing of instructions. It uses a bundle of complex instructions that in addition to basic instruction also contain information on how to run the instruction in parallel with other instructions. This greatly increases the efficiency of an EPIC processor. IA-64 (Intel Architecture-64) is Intel's first 64 bit processor based on EPIC.

## Memory Concepts

Memory is one of the most important components of a computer system as it stores data and instructions. Every memory chip contains thousands of memory locations. In the computer, the data is stored in the form of bits and bytes. A **bit** is the smallest storage unit of memory. A **nibble** is a collection of 4 bits. Eight bits combined together to form a single **byte**, which in turn represents a single character. Other units of memory are KB (Kilobyte), MB (Megabyte), GB (Gigabyte) ,TB(Terabytes), PB (Petabyte), EB (Exabytes), ZB (Zettabytes) and YB (Yottabytes). Every higher unit is equal to $2^{10}$ of the previous unit. The following table shows various units of computer memory:

| Memory unit | Relationship with earlier memory unit | In equivalent Bytes |
|---|---|---|
| Kilo Byte (KB) | 1 Kilo Byte = 1024 Bytes(or $2^{10}$ Bytes) | 1024 |
| Mega Byte (MB) | 1 Mega Byte = 1024 Kilo Byte(or $2^{10}$ KB) | 1024x1024 |
| Giga Byte (GB) | 1 Giga Byte = 1024 Mega Byte(or $2^{10}$ MB) | 1024x1024x1024 |
| Tera Byte (TB) | 1 Tera Byte = 1024 Giga Byte(or $2^{10}$ GB) | 1024x1024x1024x1024 |
| Peta Byte (PB) | 1 Peta Byte = 1024 Tera Byte(or $2^{10}$ TB) | 1024x1024x1024x1024x 1024 |
| Exa Byte(EB) | 1 Exa Byte = 1024 Peta Byte(or $2^{10}$ PB) | 1024x1024x1024x1024x 1024x1024 |

| Zetta Byte(ZB) | 1 Zetta Byte = 1024 Exa Byte(or $2^{10}$ EB) | 1024x1024x1024x1024x 1024x1024x 1024 |
|---|---|---|
| Yotta Byte(YB) | 1 Yotta Byte = 1024 Zetta Byte(or $2^{10}$ ZB) | 1024x1024x1024x1024x 1024x1024x 1024x1024 |

The computer memories can be divided into following categories:

✿ Primary Memory

✿ Secondary memory

✿ Cache Memory

**Primary Memory**

Primary memory or main memory is a Metal Oxide Semiconductor (MOS) memory used for storing program and data during the execution of the program. It is directly accessible to CPU.
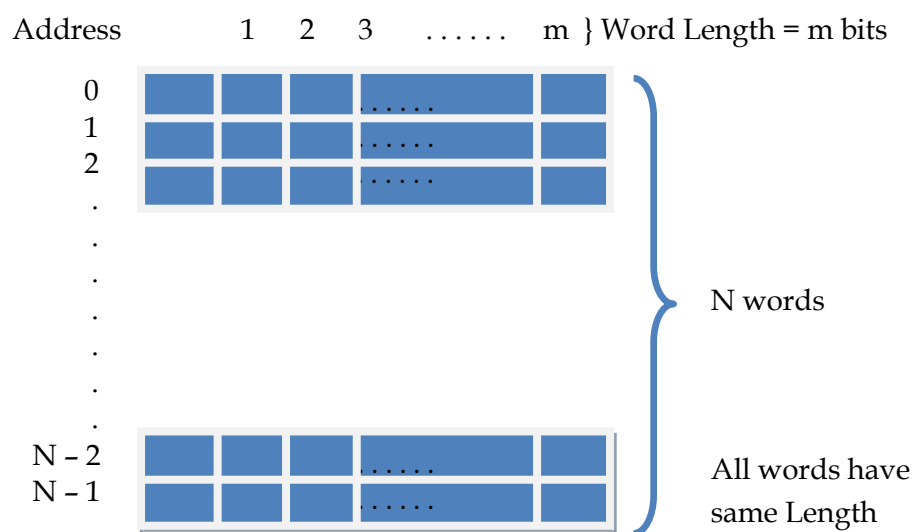


**Fig:  Organization of Main memory**

The figure above shows a high speed main memory that is organised into words of fixed lengths. A given memory is divided into N words where each word is assigned an address in the memory. A word is generally more than 8 bits in length and the number of bits in a word is termed as **word length.** Computers with 8, 16, 24 and 32 and 64 bit word length are available. The higher the word length, the more powerful a computer

is. Each word is assigned an address starting from 0 to the largest number that the computer can support. Each address uniquely specifies the memory location of a particular word. The total number of memory cells that can be uniquely addressed by CPU depends on the total number of address lines in an address bus. If there are n lines in the address bus then there are $2^n$ addressable locations in the memory.

Memories can be both read from and written to are called **read/write memories**. On the other hand memories that have data or program permanently stored onto them and hence can be only read from are called **Read Only memories**. Broadly primary memory can be of two types – RAM (Random Access Memory) and ROM (Read only memory).

### Random Access Memory (RAM)

In case of RAM, the memory can be accessed from any desired location randomly. That means without searching the entire memory, any location can be accessed in the same amount of time. The instructions and data that we input into the computer are stored in the RAM of the Computer.  It is a read/write memory, so data can be both read from and written to the RAM. It is a volatile memory and loses its contents when the power is switched off or interrupted. Nowadays RAMs are available in gigabytes. The normal memory access time of a RAM is 20-80 ns. RAM can be broadly classified into two categories:  Dynamic RAM (DRAM) and Static RAM (SRAM).

**Dynamic RAM (DRAM):**  It consists of a transistor and a capacitor that stores electric charge. The DRAMs are physically smaller, cheaper and slower memories. They are slower because the data stored in them needs to continuously refreshed and this consumes lot of processor time. Each refresh operation takes several CPU cycles to complete. This is because a capacitor tends to loose charge over a period of time which needs to be refreshed again and again. DRAM is used in primary storage areas and is available in various forms as EDORAM (**E**xtended **D**ata **O**utput RAM), SDRAM (**S**ynchronous DRAM) and DDR SDRAM.

**Static RAM:** This type of RAM is large in physical size but is an expensive and faster memory. It is faster because it is made up of flip flops to store data and these flip flops do not require any refreshing. Static RAM is also volatile and is easier to use as compared to dynamic RAM. These are used in specialized applications.

**Read only memory (ROM)**

As the name suggests, a ROM is a type of memory that can perform read operation only. The contents of ROM are written by the manufacturer and come along with the computer. We cannot change its contents or write something else on it. Data is written on to the ROM at the time of its manufacture and it cannot be changed thereafter. It is a non-volatile memory, which means that contents stored in it are not lost even when the power to the computer is switched off. ROMs are used in applications where the information once written, need not be altered. They hold certain essential instructions such as interrupt service routines or a monitor program controlling the machine. Instructions that are needed to start the computer are also stored in the ROM. ROMs are slower as compared to RAMs and are available in various types –

✡ **Programmable Read Only Memory (PROM):** This type of ROM can be programmed even after its manufacture using a PROM programmer circuit. But once a PROM is programmed, it becomes just like ROM i.e. it cannot be changed.

✡ **Erasable Programmable Read Only Memory (EPROM):** In this type of ROM, the contents can be erased and the memory can be reprogrammed. To erase the data, an EPROM is exposed to ultraviolet light and then it can be reprogrammed using a PROM programmer circuit. When the EPROM is in use, then it behaves like a ROM, that means the information can only be read.

✡ **Electrically Erasable Programmable Read Only Memory (EEPROM):** The contents of this type of ROM can be erased and then reprogrammed using electric signals. This makes it an excellent back up for RAM whose contents are lost when the power is switched off. When the power is returned, the contents of EEPROM are copied back into the RAM and the computer continues working without any data loss. Nowadays RAMs and EEPROMs are integrated in a single chip.

**Cache Memory**

Cache memory is a special high speed memory made up of high speed static RAMs. It is used to hold frequently accessed data and instructions. We know that the processing speed of CPU is much more than the main memory access time of the computer. This means the CPU has to wait for a substantial amount of time. Alternatively we have the cache memory which is a small, expensive but fast memory that is placed between the CPU and the main memory. Whenever some data is required, the CPU first looks into

cache. If data is found, we call it a **cache hit** and the information is transferred to the CPU. In case of a miss, the main memory is accessed. Memory caching proves to be efficient because most programs repeatedly access the same data and instructions, so access of frequently used data becomes very fast with cache memory. There are two types of cache memory:

✿ **L1 cache:** It is small and is built inside the CPU. It is fast as compared to L2 cache

✿ **L2 cache:** It is large but slower and is mounted on the motherboard

**Secondary Memory**

The major limitation of primary memory is that it has limited storage capacity and is volatile. To overcome this limitation we have secondary memory storage devices. This type of memory is also called external memory. It refers to the various storage media on which a computer can store data and programs. It is an additional storage, not part of the main computer.

The Secondary storage media can be fixed or removable. *Fixed Storage media* is an internal storage medium like hard disk that is fixed inside the computer. *Removable storage media* is a data storage medium that is portable and can be taken outside the computer.

**Why do we need Secondary Memory?**

Secondary memory is needed because of the following reasons:

a. **For permanence:** As the RAM is volatile, i.e. it loses all information when the electricity is turned off, something is needed for permanence. Secondary storage devices serve this purpose. They do not lose data when electricity is turned off.

b. **For portability:** Secondary storage, like the CDs, flash drives can be used to transport data from one computer to another.

**Secondary Storage Media**

There are the following main types of storage media.

a. Magnetic          b. Optical          c. Solid State

**Magnetic storage media:** Examples of magnetic storage media are hard disks, floppy disks and magnetic tapes. Magnetic media is coated with a magnetic sensitive layer and this layer is magnetized in clockwise or anticlockwise directions, which then are interpreted as binary 1s and 0s at reading.

**Floppy Disk (Diskette):** A floppy disk is a flexible disk made up of mylar with a magnetic coating on it. It is packaged inside a protective plastic envelope. These were one of the oldest type of portable storage devices that could store up to 1.44 MB of data but now they are no longer in use.

**Hard disk:** A hard disk consists of one or more circular disks called platters which are mounted on a common spindle. Each surface of a platter is coated with a magnetic material. Both surfaces of each disk are capable of storing data except the top and bottom disk where only the inner surface is used. The information is recorded on the surface of the rotating disk by magnetic read/write heads. These heads are joined to a common arm known as access arm. This arm moves over the surface of the rotating disk as shown in the figure below.
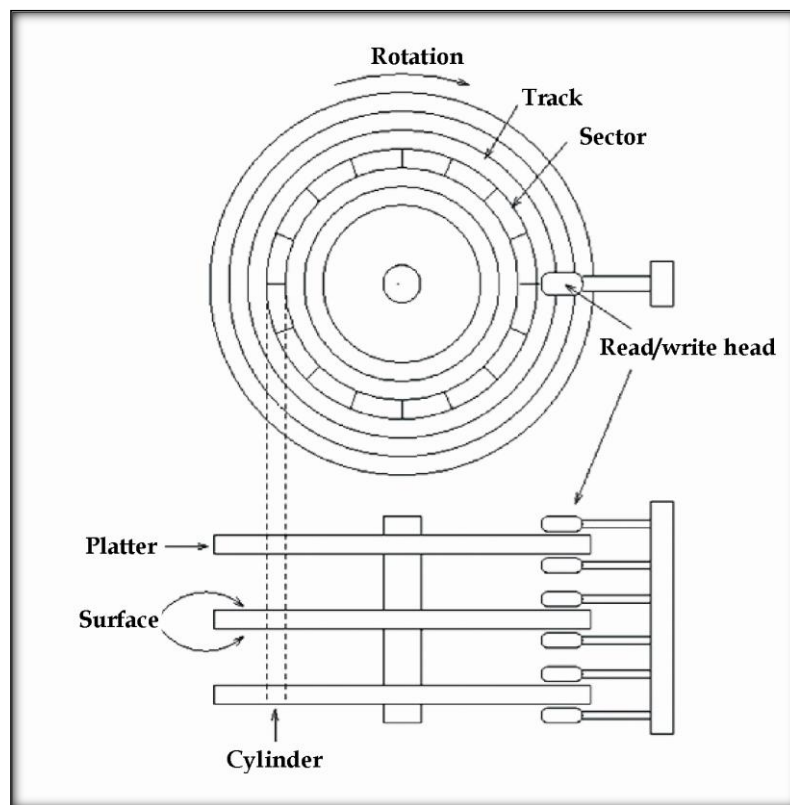


**Fig: Hard Disk**

Information is recorded on each of these disks in the form of concentric circles called tracks which are further divided into sectors. Hard drives however, are not very portable and are primarily used internally in a computer system. But external hard disks are also available as a substitute for portable storage. Today the hard disks have the storage capacity of several gigabytes to terabytes.

**Optical storage media**

On an optical storage media information is stored and read using a laser beam. The data is stored as a spiral pattern of pits and ridges denoting binary 0 and binary 1.

Examples of optical media are CDs, DVDs etc.

**Compact Disk:** A compact disk or CD can store approximately 650 to 700 megabytes (MB) of data. We must have a CD drive in our computer to read them.



**Fig: A Compact Disk**

The bits ( 0 and 1) are encoded as transitions between raised ridges and etched pits, which are lined up in a spiral like pattern. This pattern is then stamped into a 1.2-mm clear polycarbonate disc (a CD), which is then covered with a super thin coating of reflective metal (usually aluminum or gold) and a label.

To read the data, an infrared laser is beamed through the CD's polycarbonate substrate. The wavelength of light that bounces off the mirror-like reflective backing is then measured. A pit scatters the light and the ridge reflects the light. Since pits and ridges pass different amounts of light,  the fluctuations in the reflected beam are then translated back into the original ones and zeros.

**There are three types of CDs:**

**CD- ROM:** It stands for Compact Disk - Read Only Memory and data is written on these disks at the time of manufacture. Thereafter this data cannot be changed but can

only be read by a laser beam in the form of a continuous spiral. CD- ROMs are used for text, audio and video distribution like games, encyclopedias and application softwares.

**CD-R:** It stands for Compact Disk- Recordable. Data can be recorded on these disks but only once. So we can write data on these disks through a read/write CD drive but after that the disk cannot be erased/modified.

**CD-RW:** It stands for Compact Disk-Rewritable. It can be read or written multiple times. But a CD-RW drive needs to be installed on your computer.

**DVD:** It stands for Digital Versatile Disk or Digital Video Disk. It looks just like a CD and use a similar technology as that of the CDs discussed above but employ a shorter-wavelength red laser that permits a narrower beam. This allows tracks to be spaced closely enough to store data that is more than six times the CD's 700MB capacity. It is a significant advancement in portable storage technology. DVDs consist of two half-thickness (0.6-mm) CD-like discs glued back-to-back. This protects the delicate reflective coating as it is on the inside of the disc. Also it makes possible to have double-sided DVDs—where data can be stored on each half disc.

A DVD holds 4.7 GB to 17 GB of data. That means a complete movie can be stored on one side of a DVD. Like CDs DVDs also come in three varieties –

- ✡ DVD- ROM
- ✡ DVD- R
- ✡ DVD-RW

**Blue Ray Disk:** This is the latest optical storage media to store high definition audio and video. It looks like a CD or DVD but can store up to 27 GB of data on a single layer disk and up to 54 GB of data on a dual layer disk. Where CDs or DVDs use red laser beam, the blue ray disk uses a blue laser to read/write data on a disk.



**Fig: Blue ray Disk**

As the wavelength of the blue ray is shorter, more data per unit area can be stored on the disk. This is because due to shorter wavelength, it is possible to focus the laser spot with greater precision. Hence data can be packed more tightly. Blue-ray Disc (BD) was developed to enable recording, rewriting and playback of high-definition video (HD), as well as storing large amounts of data.

**Solid State Memories**

The term 'solid-state' essentially means 'no moving parts'. Hence Solid-state storage devices are based on **electronic circuits** with **no moving parts** (no reels of tape, no spinning discs, no laser beams, etc.) Solid-state storage devices store data using a special type of memory called flash memory. SSD, Solid-state drive (or flash memory) is used mainly in digital cameras, pen drives or USB flash drives.

**Pen Drives:** Pen Drives or Thumb drives or Flash drives are the recently emerged portable storage media. It is an EEPROM based flash memory which can be repeatedly erased and written using electric signals. This memory is coupled with a USB connector through which it can be plugged into the computer. They have a capacity smaller than a hard disk but greater than a CD.



**Fig : A pen Drive**

## Input Output Ports and Connections

Let us look at the back of a CPU. Computer ports are the points where external devices or peripherals connect to a computer. These ports are available at the rear or front of the computer. We connect peripherals to the computer with a cable that attaches to one of the ports.
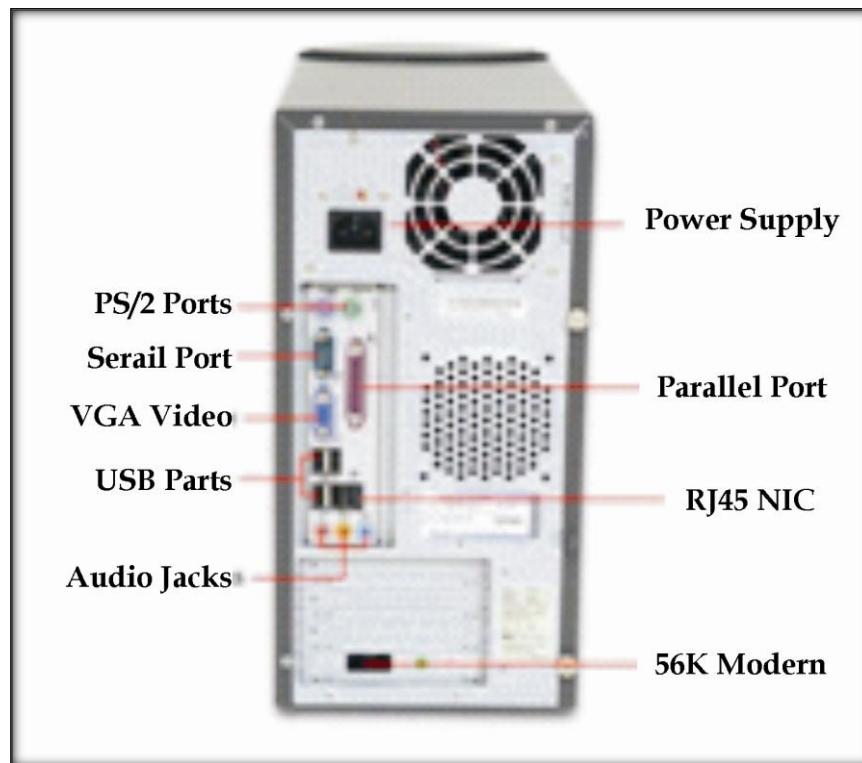
**Fig: Ports at the back of CPU**

A port's main function is to act as a point of attachment where the cable from the peripheral device plugs into the system unit, allowing data to flow from the peripheral device. Some of the common sockets/ports are power socket for connecting power cable, PS2 ports for connecting Mouse & Keyboard, USB Port for connecting USB devices such as mouse, keyboard, printer, pen drive etc. and VGA port for connecting Monitor/Screen.

**Some ports are discussed in detail below:**

## Serial Port

Through a serial port data is transmitted travels one bit at a time through a single wire. The data transmission speed is quite slow. Serial ports are commonly known as communication (COM) ports or RS232C ports and connect devices like mouse and modem. These ports are rarely used these days.
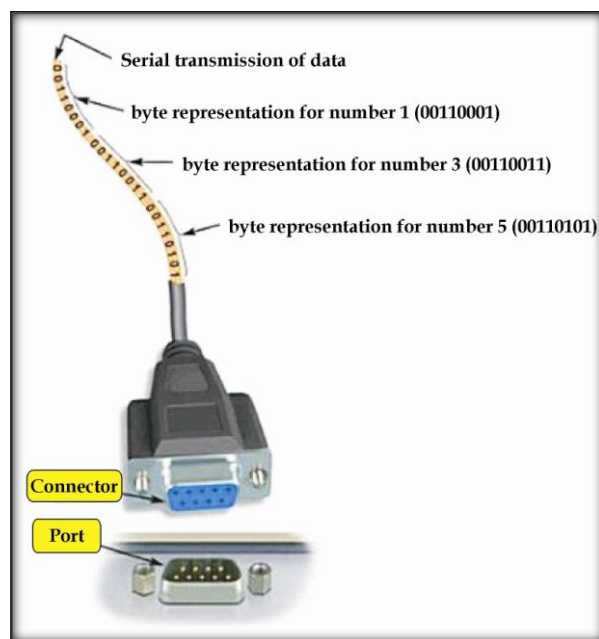
**Fig: Serial Port**

## Parallel port

These ports were earlier used to connect printers to the computer system. A parallel port can send 8 bits (1 byte) at a time simultaneously (in parallel). Hence data transmission is faster through these ports. Parallel ports are used to connect printers, scanners, CD writers etc.
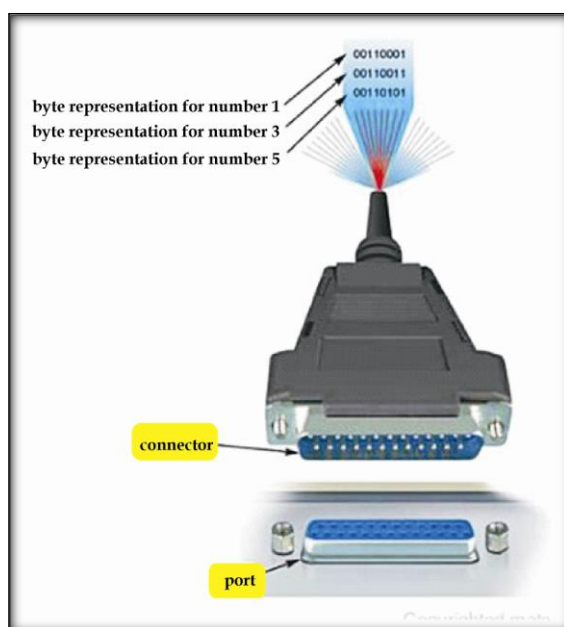


**Fig: Parallel Port**

### PS/2 Port

This is a round port for plugging in keyboard or mouse. It has a PS/2 cable with a mini DIN connector. These ports are becoming obsolete now. In fact some systems these days do not have PS/2 ports.
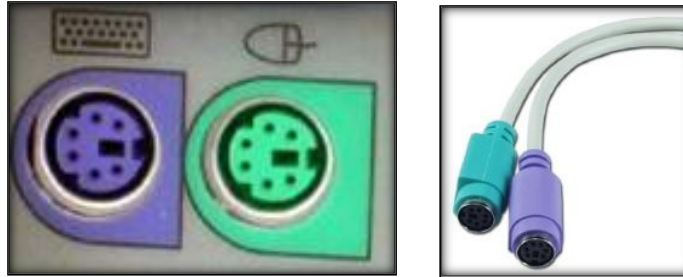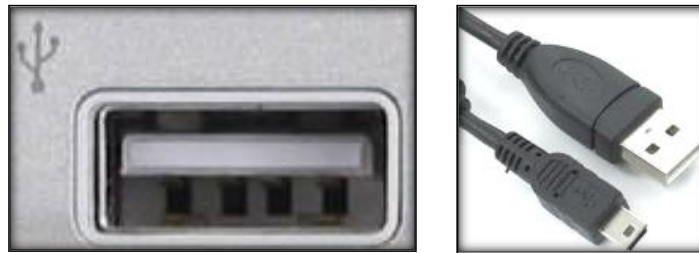


**Fig: PS/2 port**

### USB Port



**Fig: USB Port**

A USB (Universal Serial Bus) port is a standard cable connection interface available on personal computers and some other electronic devices for data communication. It is a single, low cost, plug n play connector. The operating system automatically detects the device connected through the USB port. USB ports have become very popular these days as they connect many different devices to the computer these days. Most computers have USB ports on front, back and/or sides of system unit. Flash drives, digital cameras, printers, scanners are some of the devices that often connect through the USB port.

### Infrared Port

In this type of port, data is transmitted through Infrared waves. For infrared transmission the device and the computer both must have infrared ports. These allow

computers and peripherals to communicate serially over an Infrared link rather than over cables. The remote control of our TV sets uses the same technology. For wireless data communication between computers and various peripheral devices we use infrared ports.

## Bluetooth Port

Bluetooth is used to connect mobile phones, computers and PDAs using a short range wireless connection. This technology uses radio waves to transmit data between any two devices. The devices that are Bluetooth enabled contain a small transceiver chip that allows them to communicate with other Bluetooth enabled computer or device. Data can be exchanged at the rate of about 2 megabit per second.
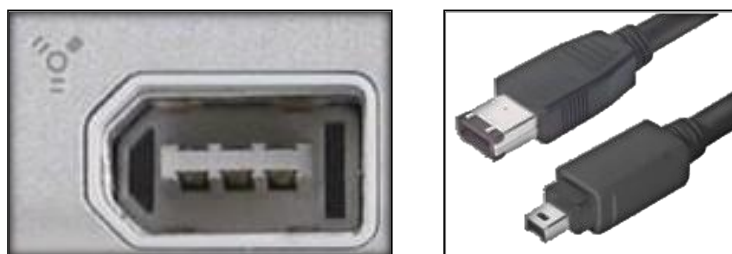
## Fire wire Port



**Fig: A Firewire port**

FireWire® ports are forms of a serial port that make use of FireWire® technology to transfer data rapidly from one electronic device to another. The FireWire® port has the ability to interact with a number of different devices since it provides a single plug and socket connection for all devices. A FireWire® port can provide an ideal way to connect a scanner and digital camera/camcorder to a computer system as the data transfer is relatively faster than on USB and also results in excellent quality.

## EXCERCISE

a)     Define word length of a microprocessor.

b)     Name the two types of Primary Memory.

c)     What is the purpose of System Clock?

d)     Differentiate between CISC and RISC processors.

e)     Why do we use secondary storage? Name any two secondary storage devices.

f)     How is Computer's internal memory important?

g)     Why is it more appropriate to call RAM as Read-Write memory?

h)     What is the purpose of Cache memory?

i)     Explain in brief the different ports and their purposes.

j)     Distinguish between the following pairs:

    a.     Primary memory and Secondary memory

    c.     RAM and ROM

    d.     Bluetooth and Infrared port