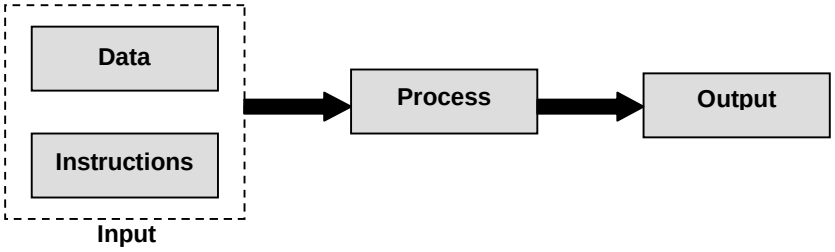
# Chapter One
# Introduction

## What is a Computer?

A computer is any calculating device or machine, which is electrical, mechanical or electromechanical. But that doesn't mean that computer performs only calculation. The name computer comes from a Latin word computer, meaning "to reckon" or "to compute" and can be applied to abacus or any adding machine as to the modern computer. However, the term Computer has come to mean a special electronic device having certain definite characteristics.

Stated simply, it is **an electronic device which processes information based on the instructions provided, to generate the desired output**. It, therefore, requires two types of input – raw data, and the set of instructions to process or act upon the data.

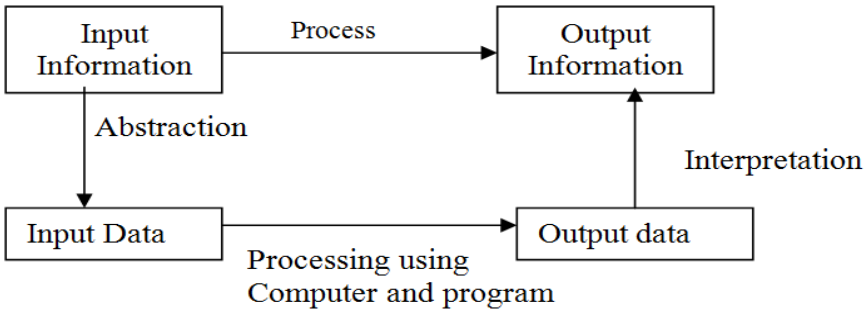
The following figure is a schematic view of the Computer:




Data can be of any type – text, numeric, alpha-numeric, image, picture, sound etc. The instructions that act upon this data are also called the **program** or **software** in computer terminology.

**Computer Science** is a science concerned with information, that is, representation, storage, manipulation or processing and presentation of information. Like any other science, which uses different devices and lab equipment, Computer Science uses a special device called COMPUTER.

The following figure shows the processing of information.




The main idea and objective of the processing is:

- Solving a problem
- Simplifying the way a task is performed.

Computer science has different fields of specialization or sub-disciplines like other sciences. There are seven sub-disciplines of computer science.

**Software engineering**: Concerned with how to use and apply scientific and basic engineering principles to solve problems faced by programmers and to select the best way so as to produce a high quality software or program.

**Computer engineering (Architecture)**: deals with studying, analyzing and designing of computer hardware (organization and interconnection of computer system components) and its working principle.

**Automata theory**: concerned with the study of machines, devices or models, which has a certain set of inputs and outputs (which depends only on the inputs). It is the abstract study of computers and their efficiency.

**Formal language theory**: concerned with the study of grammars of programming languages, which helps in understanding and construction of programming languages and compilers.

**Complexity theory**: concerned with the study and analysis of algorithms, which helps in measuring the efficiency of the algorithms.

**Database Architecture**: deals with the study of and design of efficient methods of information storage and retrieval.

**Artificial Intelligence**: a recent sub-discipline concerned with how to design and program machine to solve problems or carried out tasks that appear to require human imagination or intelligence.

## Characteristics of Computers

What makes the computer distinguishable from other devices?

The characteristics of computers that have made them so powerful and universally useful are speed, accuracy, reliability, diligence, versatility and storage capacity.

***Speed:*** Computers work at an incredible speed. The speed with which it performs is beyond human capabilities. As a comparison, it can do in one minute what a human being would probably take a lifetime! When we refer to the speed of computers, we talk in terms of milliseconds (hundredth of a second), microseconds (millionth of a second), nanoseconds (billionth of a second), and even picoseconds (trillionth of a second). A powerful computer is capable of performing about 3-4 million simple instructions per second.

***Accuracy:*** In addition to being fast, computers are also accurate. Errors that may occur can almost always be attributed to human error (inaccurate data, poorly designed system or faulty instructions/programs written by the programmer) rather than technological weaknesses.

***Reliability:*** Computers work on instructions or programs as instructed without any failure.

***Diligence:*** Unlike human beings, computers are highly consistent. They do not suffer from human traits of boredom and tiredness resulting in lack of concentration. Computers, therefore, score high over human beings in performing voluminous and repetitive jobs.

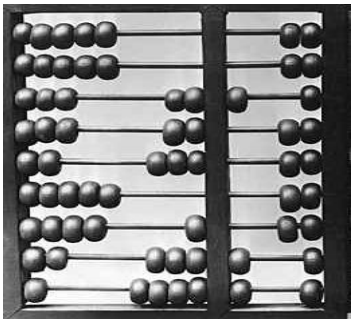
***Versatility:*** Computers are versatile machines and are capable of performing any task as long as it can be broken down into a series of logical steps. This means that their capability is, once again, limited only by human intelligence. As is evident, in today's fast developing technology-world, it is almost inconceivable to find an area where computers are not being used. The presence of computers can be seen in every sphere – Railway/Air reservation, Banks, Hotels, Weather forecasting and many more.

***Storage Capacity:*** Today's computers can store volumes of data. Unlike human memory where unimportant information is relegated to the back of the mind and forgotten as time progresses, a piece of information once recorded (or stored) in the computer, can never be forgotten and can be retrieved almost instantaneously! Information can, therefore, be retained as long as desired (using secondary storage – a type of detachable memory).

## History of Computers

The history of computers can be traced back to almost 2000 years ago, with the advent of abacus, a wooden rack holding two horizontal wires with beads strung on them. Numbers are represented using the position of beads on the rack. Fast and simple calculations can be carried out by appropriately placing the beads.

In 1620, an English mathematician by the name William Oughtred invented the slide rule – a calculating device based on the principle of logarithms. It consisted of two graduated scales devised in such a manner that suitable alignment of one scale against the other, made it possible to perform additions, compute products etc. just by inspection.



*The Abacus*

Blaise Pascal, a French mathematician, is usually credited for building the first digital computer in 1642. He invented the mechanical calculating machine. Numbers were entered in this machine by dialing a series of numbered wheels. Another series of toothed wheels transferred the movements to a dial, which showed the results.

In 1671, Gottfried von Leibnitz, a German mathematician, invented a calculating machine which was able to add and perform multiplications. He invented a special stepped gear mechanism for introducing the addend digits, which is still being used.

The prototypes made by Pascal and Leibnitz were not used in many places. It was only about a century later that Thomas of Colmar created the first successful mechanical calculator which could add, subtract, multiply, and divide. A lot of improved desktop calculators by various inventors followed, such that by 1890 a range of improvements like accumulation of partial results, storage of past results, and printing of results were not uncommon.

## The First Computer

Charles Babbage, a professor of mathematics at Cambridge University, England, realized that many long calculations usually consisted of a series of actions that were constantly repeated and hence could possibly be automated. By 1822, he designed an automatic calculating machine that he called the 'Difference Engine'. It was intended to be steam powered and fully automatic (including printing of result tables), commanded by a fixed instruction program. In short, he developed a prototype of a computer which was 100 years ahead of time and is, therefore, considered as the father of modern day computers.

A step towards automated computing was the development of punched cards which were first successfully used by Herman Hollerith, who worked in the US Census Bureau in 1890. He along with James Powers developed devices that could read information that had been punched into cards, without any human help. This resulted in reduced reading errors, increased workflow and availability of unlimited memory (punched cards could be used as easily accessible memory of unlimited size).

These advantages were seen by various commercial companies and soon led to the development of improved punch-card using computers by companies like International Business Machines (IBM) and Remington.

## Some Well Known Early Computers

### Mark I

After World War II there was a need felt for advanced calculations. By that time, many reliable mechanical desk calculators had been developed. Howard A. Aiken of Harvard University, while working on his doctorate in physics, in the year 1937, designed a machine that could automatically perform a sequence of arithmetic operations. He completed this in 1944 and named it Mark I. This machine performed a multiplication and division at an average of about four and eleven seconds respectively. The results were printed at a rate of one result per five seconds.

### ENIAC

The World War II also produced a large need for computer capacity especially for the military.

New weapons were made for which trajectory tables and other essential data were needed.

In 1942, Professors John P. Eckert and John W. Mauchly at the Moore School of Engineering of the University of Pennsylvania, USA, decoded to build a high speed computer to do the job. This was called the Electronic Numeric Integrator and Calculator (ENIAC).

It used 18,000 vacuum tubes, about 1,800 square feet of floor space, and consumed about 180,000 watts of electrical power. It had punched cards I/O and its programs were wired on boards.

ENIAC is accepted as the first successful high-speed electronic digital computer and was used from 1946 to 1955.

### EDVAC

Fascinated by the success of ENIAC, John Von Neumann, a mathematician, undertook an abstract study of computation in 1945. In this he aimed to show that a computer should be able to execute any kind of computation by means of a proper programmed control. His ideas, referred to as 'stored program technique', became essential for future generations of high-speed digital computers and were universally accepted. The basic idea behind the stored program concept was that data as well as instructions can be stored in the computer's memory to enable automatic flow of operations.

Between 1947 and 1950, the More School personnel and the Ballistics Research Laboratory of the US army built a computer named Electronic Discrete Variable Automatic Computer (EDVAC), which was based on Von Neumann's concept of stored program.

### UNIVAC

The Universal Automatic Computer (UNIVAC), developed in 1951, was the first digital computer to be produced and was installed in the Census Bureau.

The first-generation stored-program computers needed a lot of maintenance, reached 70% to 80% reliability of operations and were used for almost 10 years. EDVAC and UNIVAC fell into this group of computers and were the first commercially available computers.

## Computer Generations

'Generation' in computer terminology is a 'step' ahead in technology. As you go through the history of evolution of computers, you will find that the earliest computers were big in size, consumed a lot of power and heated up quickly, due to which it had to be shut down, frequently to be cooled. They were very expensive in terms of development and maintenance.

As technology improved, computers became compact, faster and more powerful. From a user's perspective, they become user friendly and more affordable. This has largely contributed towards the popularity that computers have gained these days.

The term 'generation' was earlier used only to distinguish between varying hardware technologies but was later extended to include both hardware and software. A comparison of generations is made below.

a) **First Generation Computers (1940 to 1956):-** The first generation of computers was characterized by **vacuum tubes** in the circuitry and magnetic drums for memory.

   These computers were enormous in size, used great deal of electricity and were expensive to operate. They also had limited storage capacity.

First generation computers relied on machine language (binary-coded program) to perform operations and could solve only one problem at a time. Punched cards and paper tapes were used to input data and instructions, and output was displayed on printouts.

Early computers like ENIAC, EDVAC and UNIVAC can all be classified as first generation computers.

**b) Second Generation Computers (1956 to 1963):-** In the early 1950s, the discoveries of **Transistor** and **Magnetic core memory** changed the image of computers – from unreliable to highly reliable machines with increased capability, and higher storage capacity.

The transistor was far superior to the vacuum tube, allowing computers to become smaller in size, cheaper, reliable and more energy efficient. Though transistor still generated a great deal of heat, it was a substantial improvement over the vacuum tube.

Second generation of computers was also characterized by allowing programmers to specify instructions in symbolic (or assembly) language rather than cryptic binary machine language. High level programming languages like **CO**mmon **B**usiness **O**riented **L**anguage **(COBOL)** and **FOR**mula **TRAN**slation **(FORTRAN)** were also being developed at this time.

Due to the increase in the cost of expanding programming, these machines were expensive to purchase and operate. Such computers were, therefore, mostly found in large computer centers or government/private laboratories with many programmers and support professionals.

**C) Third Generation Computers (1964 to 1971);-** The development of **Integrated Circuit** by ***Jack Kilby***, an engineer with Texas Instruments, in 1958, was the hallmark of the third generation of computers. Punched cards and printouts gave way to devices like keyboards and monitors making it easier for the user to interact with the computer. Computer manufacturers could provide a range of accessories like the cathode ray tube display devices, page printers, consoles etc.

Existence of an **operating system** allowed the device to run various applications at one time with the central program monitoring the memory.

For the first time, computers were being widely used in business for areas like Accounting, Payroll, Billing, Tracking Inventory, etc. Third generation computers were substantially smaller and cheaper than their predecessors.

**D) Fourth Generation Computers (1971 to present):-** The trend in 1970s was to move from single-purpose but powerful computers towards cheaper computer systems that could support a large range of applications.

A new revolution in computer hardware came about which could shrink the computer logic circuitry and its components using the Large Scale Integration (LSI) technology. Hundreds of components could now fit onto a single chip!

In the 1980s, **V**ery **L**arge **S**cale **I**ntegration (VLSI) squeezed hundreds of thousands of components onto a single chip. This shrinking trend continued and led to the introduction of personal computers (PCs) – programmable machines that are small enough and inexpensive so that these can be purchased and used by individuals. Companies like Apple Computers and IBM introduced very successful PCs.

The IC technology was not only used to construct the processor, but also for the construction of memory. The first memory chip was constructed in 1970 and could hold 256 bits.

E) **Fifth Generation Computers (the Road Ahead):-** The fifth generation of computers characterized by artificial intelligence is in the process of development. The goal here is to develop devices that are capable of learning and responding to natural language input.

This generation of computers is using new technologies in very large scale integration, along with new programming languages and will be capable of amazing feats, in the area of artificial intelligence, such as voice recognition.

**SUMMARY**

| Computer Generation | Technology Used | Speed | Storage Capacity | Programming Language |
|---|---|---|---|---|
| First | Vacuum tubes | Slow | Limited | Symbolic language |
| Second | Transistors | Relatively faster | Increased storage capacity | High Level Languages (e.g. COBOL, FORTRAN) |
| Third | Integrated Circuits (ICs) | Better performance, Remote processing and time sharing | Increased storage | Extensive use of High Level Languages |
| Fourth | Large scale and very large scale integrated circuits (LSI, VLSI) | Considerably faster | Increased storage | Sophisticated programs and languages for special applications |
| Fifth | Use of ICs with ultra large scale integration technology (ULSI) | Extremely fast | Larger capacity storage (RAID, optical disks) | Based on Artificial Intelligence |

## Classifications of Computers

### I. Classification according to Data Handling capability

#### a) Analog Computers

The analog signal is usually represented by series of sine waves. These signals are of varying frequency or amplitude. Analog technology is used by broadcast and telephone transmission conventionally. These computers recognize data as a continuous measurement of a physical property (voltage, pressure, speed and temperature).

Analog computer example includes automobile speedometer, a furnace thermostat and mechanical watch. Also flowing of electric current & voltage etc. are common example of analog computer. They are basically used in process industry and instruments that can directly measure.

#### b) Digital Computers

Digital computers are high speed, programmable, electronic devices that perform mathematical calculations, compare values and store the results. They recognize data by counting discrete signal representing either a high ("on") or low ("off") voltage state of electricity. Numbers and special symbols can be reduced to representation by 1's ("on) and 0's ("off"). In case of digital technology the signal that travels can be represented in terms of two states-positive (1) and non-positive (0). Each of these state digits is referred to as bit.

The digital computers are used for measuring data in digital form. The real life example of digital computer is a digital watch. Now a day, computer used for the purpose of business and education are also example of digital computers. In digital computers, data flows in the form of pulses.

#### c) Hybrid Computers

A computer that processes both analog and digital data. The use of hybrid computers is increasing day by day as there are number of areas in the real world where we need both analog and digital computers.

As an example, in hospitals there may be number of devices like E.C.G. machine etc. which are used to measure the person's heart beat, temperature and other information. This is done by analog computers. The information received from these devices is then supplied to digital computers to generate reports.

### II. Classification according to size

#### a) Supercomputers

Supercomputers are widely used in scientific applications such as aerodynamic design simulation, processing of geological data. Supercomputers are the most powerful computers. They are used for problems requiring complex calculations. Because of their size and expense, supercomputers are relatively rare.

Supercomputers are used by universities, government agencies, and large businesses. It can process trillions of instructions in seconds. This computer is not used as a PC in a home neither by a student in a college. Supercomputers have been designed to do complex calculations at faster speeds than other computers.

Its designers make use of 2 processes for the enhancement of its performance. The first method is called pipelining. It does complex operations at the same time by grouping numbers which have the same order that it calculates and these are passed to the CPU in an orderly manner. The circuits in the CPU continuously perform the operations while data is being entered into it.

Another method used is called parallelism. It does calculations in a similar orderly way. This is where it performs various data's at the same time and moves ahead step by step. A usual way to do it is connecting together various CPUs which do calculations together. Each of these CPUs does the commands it needs to carry out on every piece of information.

USES: Supercomputers are used for highly calculation-intensive tasks such as problems involving quantum mechanical physics, weather forecasting, climate research (including research into global warming), molecular modeling (computing the structures and properties of chemical compounds, biological macromolecules, polymers, and crystals), physical simulations (such as simulation of airplanes in wind tunnels, simulation of the detonation of nuclear weapons, and research into nuclear fusion), cryptanalysis, and the like. Major universities, military agencies and scientific research laboratories are heavy users.

### b) Mainframe Computers

Mainframe computers are usually slower, less powerful and less expensive than supercomputers. A technique that allows many people at terminals, to access the same computer at one time is called time sharing. Mainframes, for example, are used by banks and many businesses to update inventory.

Mainframe computers can support hundreds or thousands of users, handling massive amounts of input, output, and storage.

Mainframe computers are used in large organizations where many users need access to shared data and programs.

They are also used as e-commerce servers, handling transactions over the Internet. Another giant in computers after the super computer is Mainframe, which can also process millions of instruction per second and capable of accessing billions of data.

Mainframes are computers used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, ERP, and financial transaction processing.

The term probably originated from the early mainframes, as they were housed in enormous, room-sized metal boxes or frames. Later the term was used to distinguish high-end commercial machines from less powerful units.

**Speed and performance**: The CPU speed of mainframes has historically been measured in millions of instructions per second (MIPS). MIPS have been used as an oversimplified

comparative rating of the speed and capacity of mainframes. The smallest System z9 IBM mainframes today run at about 26 MIPS and the largest System z10 at about 30,657 MIPS - a 1 to 1179 performance capacity ratio. This computer is also commonly used in big hospitals, air line reservations companies, and many other huge companies prefer mainframe because of its capability of retrieving data on a huge basis.

### c) Minicomputers

Minicomputers are smaller than mainframe, general purpose computers, and give computing power without adding the prohibitive expenses associated with larger systems. It is generally easier to use. They usually have multiple terminals.

Minicomputers may be used as network servers and Internet servers.

A minicomputer (colloquially, mini) is a class of multi-user computers that lies in the middle range of the computing spectrum, in between the largest multi-user systems (mainframe computers) and the smallest single-user systems (microcomputers or personal computers). The class at one time formed a distinct group with its own hardware and operating systems, but the contemporary term for this class of system is midrange computer, such as the higher-end SPARC, POWER and Itanium-based systems from Sun Microsystems, IBM.

Minicomputers are introduced in the early 1960s and announced a new era in computing. They are relatively low cost and small. This setup allowed more people to have access to computers and as a result a spurt of new applications in universities, industry, and commerce are created. Digital Equipment Corporation developed the PDP-1 minicomputer in 1960, and the PDP-8 virtually conquered the market is a sweep and sold over 40,000 units.

A minicomputer is an intermediate computer, in terms of size and power between the mainframes and the microcomputers. The term ‘minicomputer’ is now obsolete and the computers that fall in this category are now referred to as midrange servers.

A minicomputer is a multiprocessing system capable of supporting from 4 to about 200 users simultaneously.

### Workstations

A type of computer used for engineering applications (CAD/CAM), desktop publishing, software development, and other types of applications that require a moderate amount of computing power and relatively high quality graphics capabilities.

Workstations generally come with a large, high-resolution graphics screen, at least 64 MB (megabytes) of RAM, built-in network support, and a graphical user interface. Most workstations also have a mass storage device such as a disk drive, but a special type of workstation, called a diskless workstation, comes without a disk drive. The most common operating systems for workstations are UNIX and Windows NT.

Workstations lie between personal computers and minicomputers, although the line is fuzzy on both ends. High-end personal computers are equivalent to low-end workstations. And high-end workstations are equivalent to minicomputers.

Like personal computers, most workstations are single-user computers. However, workstations are typically linked together to form a local-area network, although they can also be used as stand-alone systems.

In networking, workstation refers to any computer connected to a local-area network. It could be a workstation or a personal computer.

Workstation, such as a Unix workstation, RISC workstation or engineering workstation, is a high-end microcomputer designed for technical or scientific applications. Workstations are intended primarily to be used by one person at a time, although they are commonly connected to a local area network and run multi-user operating systems.

Historically, workstations offered higher performance than normally seen on contemporary personal computers, especially with respect to graphics and CPU power, memory capacity and multitasking ability.

Workstations are often optimized for displaying and manipulating complex data such as 3D mechanical design, engineering simulation results such as for computational fluid dynamics, animation and rendering of images, and mathematical plots. Consoles usually consist of a high resolution display, a keyboard and a mouse at a minimum, but often support multiple display.

### d) Microcomputers or Personal Computers

Microcomputer is the smallest, least expensive of all the computers. Micro computers have smallest memory and less power, are physically smaller and permit fewer peripherals to be attached.

Microcomputers are more commonly known as personal computers. The term “PC” is applied to IBM-PCs or compatible computers. Desktop computers are the most common type of PC. Notebook (laptop) computers are used by people who need the power of a desktop system, but also portability. Handheld PCs (such as Personal Digital Assistants, PDAs) lack the power of a desktop or notebook PC, but offer features for users who need limited functions and small size.

A microcomputer is a computer with a microprocessor as its central processing unit. Another general characteristic of these computers is that they occupy physically small amounts of space when compared to mainframe and minicomputers. Many microcomputers (when equipped with a keyboard and screen for input and output) are also personal computers (in the generic sense).

## III. Classification according to Purpose

### a) General purpose Computers

A ‘General Purpose Computer’ is a machine that is capable of carrying out some general data processing under program control.

It refers to computers that follow instructions, thus virtually all computers from micro to mainframe are general purpose. Even computers in toys, games and single-function devices follow instructions in their built-in program.

### b) Special purpose Computers

A computer that is designed to operate on a restricted (specific) class of problems. The use of special purpose computer equipment to obtain patient diagnostic information is an example.

## Computer Capabilities and Limitations

Like all machines, a computer needs to be directed and controlled in order to perform a task successfully. Until such time as a program is prepared and stored in the computer's memory, the computer 'knows' absolutely nothing, not even how to accept or reject data. Even the most sophisticated computer, no matter how capable it is, must be told what to do. Until the capabilities and the limitations of a computer are recognized, its usefulness cannot be thoroughly understood.

In the first place, it should be recognized that computers are capable of doing repetitive operations. A computer can perform similar operations thousands of times, without becoming bored, tired, or even careless.

Secondly, computers can process information at extremely rapid rates.

Thirdly, computers may be programmed to whatever level of accuracy is specified by the programmer. These machines are very accurate and reliable especially when the number of operations they can perform every second is considered. Because they are man-made machines, they sometimes malfunction or break down and have to be repaired. However, in most instances when the computer fails, it is due to human error and is not the fault of the computer at all.

In the fourth place, general-purpose computers can be programmed to solve various types of problems because of their flexibility. One of the most important reasons why computers are so widely used today is that almost every big problem can be solved by solving a number of little problems - one after another.

Finally, a computer, unlike a human being, has no intuition. A person may suddenly find the answer to a problem without working out too many of the details, but a computer can only proceed as it has been programmed to.

Applications of Computers (Left as a reading assignment!)