## 1.1 DEFINITION OF COMPUTER

Computer is an electronic device that takes input data from the user and processes these data under the control of set of instructions (program) and gives the desired result as output and may saves output for the future use.

### *Functions of Computer*
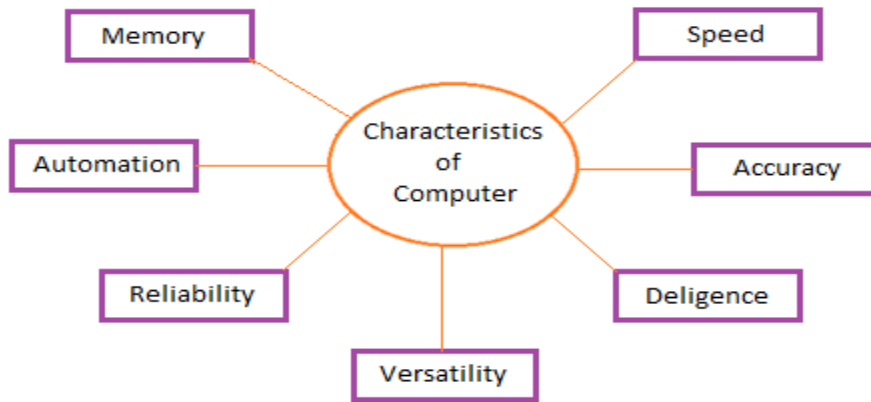
1. Accepts data (Input).                 2. Processes data (Processing).
3. Produces result (Output).             4. stores results (Storage)
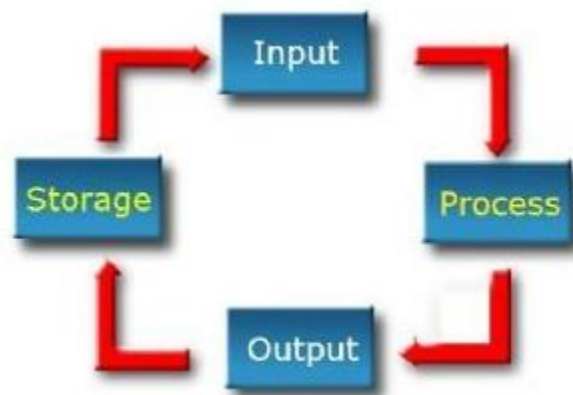


## 1.2 CHARACTERISTICS OF COMPUTERS

Computer has the following characteristics

- **Accuracy**
- **Diligence**
- **Versatility**
- **Reliability**
- **Automation**
- **Storage**

## Speed

- A computer works with much higher speed compared to humans
- Computers can process millions of instructions per second.
- The time taken by computers for their operations is microseconds and nanoseconds.

## Accuracy

- Computers perform calculations with 100% accuracy.
- Errors that may occur can almost always be attributed to human error.
- Inaccurate data, poorly designed system or faulty programs written by the programmer

## Diligence

- Computers are highly consistent.
- They do not suffer from human traits of boredom and tiredness, lack of concentration.
- Computers can perform 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.
- Computer to perform different kinds of works with same accuracy and efficiency.

## Reliability

- A computer is reliable as it gives consistent result for similar set of data
- we give same set of input any number of times, we will get the same result.

## Automation

- Computer performs all the tasks automatically.It performs tasks without manual intervention.

*Memory/Storage*

- Computers can store large volumes of data.
- A piece of information once recorded (or stored) in the computer, can never be forgotten and can be retrieved almost instantaneously.

# 1.3 APPLICATION OF COMPUTER

The computer used in various application area  inthe world.

1. Business
2. Education
3. Marketing
4. Banking
5. Insurance
6. Communication
7. Health Care
8. Military
9. Engineering Design

### › *Business*
A computer has an integrated part in all business or non-business organizations.
Ex: Payroll calculations, Sales analysis, Budgeting, Financial forecasting, Managing employees database and Maintenance of stocks etc.

### › *Education*
Computers have its dominant use in the education field to enhance performance in learning.
Even distance learning is made effective through internet and video-based classes.
Researchers have massive usage of these computers in their scholarly work.

### › *Marketing*
Advertising marketing with computers, advertising professionals create art and graphics, write and revise copy, and print and disseminate ads with the goal of selling more products.

Computerized catalogues that provide access to product information and permit direct entry of orders to be filled by the customers. the computer used to prints the  magazines, , newspapers, books and many others.

### › *Banking*
Today banking is almost totally dependent on computer. Banks provide online accounting facility, which includes current balances, deposits, overdrafts, interest charges, shares, and trustee records.
ATM machines are making it even easier for customers to deal with banks.

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

### › *Communication*

Communication means to convey a message, an idea, a picture or speech that is received and understood clearly and correctly by the person for whom it is meant for. Some main areas in this category are: Chatting, E-mail, Usenet, FTP, Video-conferencing and Telnet.

### › *Health Care*

Most of the medical information can now be digitized from the prescription to reports. Computation in the field of medicine allows us tooffer varied miraculous therapies to the patients. software used to examine the internal organs of the human body.  ECG's, radiotherapy done with the help of computers.

### › *Military*

Computer builds the links between the soldiers and commanders through the satellite. Construction of weapons and controlling their function is not possible without the aid of computers. The list of the criminals and the records of the cops are maintained regularly in the system.

### › *Engineering Design*

computers aid in designing buildings, automobiles, electrical and electronics. The construction layouts are designed beautifully on system using different tools and software's.

## 1.4 GENERATION OF COMPUTER

The history of the computer goes back several decades. CharlesBabbage is known as father of computer he has invented first analytical computer in year 1822.however, and there are five definable generations of computers.Each generation is defined by a significant technological development that changes fundamentally how computers operate – leading to more compact, less expensive, but more powerful, efficient and robust machines.

1. First Generation (1946 - 1959)
2. Second Generation (1959 - 1965)
3. Third Generation (1965 - 1971)
4. Fourth Generation (1971 - 1980)
5. Fifth Generation (1980 onwards)

**FIRST GENERATION- *Vacuum Tubes(1946-1959)***

1. These early computers used vacuum tubes as circuitry and magnetic drums for memory.
2. These computers relied on 'machine language.
3. These computers could calculate in milliseconds.
4. The two notable machines of this era were the UNIVAC and ENIAC machines
5. These were very big in size, costly.Need a cooling system.

**SECOND GENERATION-Transistors1959-1965**

1. Due to the presence of transistors instead of vacuum tubes,.
2. This reducing the size of a computer.
3. Assembly language and punch cards were used for input.
4. Better speed, portability. calculate data in microseconds.
5. A cooling system, Constant maintenance was required.

### THIRD GENERATION– Integrated Circuits1965-1971
1. the transistors were now being miniaturized and put on silicon chips (called semiconductors).
2. These computers were cheaper as compared to second-generation computers.
3. they were fast and reliable. small size of the computer big storage capacity.
4. IC not only reduce the size of the computer but it also improves the performance of the computer as compared to previous computers.
5. Instead of punch cards, mouse and keyboard are used for input.
6. They used an operating system for better resource management and used the concept of time-sharing and multiple programming.
7. These computers reduce the computational time from microseconds to nanoseconds.
8. IC chips are difficult to maintain. Air conditioning is required.

### FOURTH GENERATIONMicroprocessors1971-1980.

1. Fastest in computation and size get reduced as compared to the previous generation of computer.
2. Small in size as compared to previous generation computers.
3. Less maintenance is required.
4. All types of high-level language can be used in this type of computers.
5. The Microprocessor design and fabrication are very complex.
6. Air conditioning is required in many cases due to the presence of ICs.

### FIFTH GENERATIONArtificial Intelligence1980-onwards

1. Computer devices with artificial intelligence are still in development,
2. AI is a reality made possible by using parallel processing and superconductors. It is support voice recognition. quantum computation, molecular and nano technology.
3. Which can process and respond to natural language, and have capability to learn and organise themselves.
4. this generation is based on ULSI(Ultra Large Scale Integration) technology resulting in the production of microprocessor chips having ten million electronic component
5. It is more reliable and works faster.
6. It is available in different sizes and unique features.
7. It provides computers with more user-friendly interfaces with multimedia features.

## 1.5 TYPES OF COMPUTER

Computers vary widely in terms of their size and purpose they serve. There are very small computers that can be held on a palm. There are also large computers that take a whole room to occupy.

1. **Micro Computer**
2. **Mini Computer**
3. **Mainframe Computer**
4. **Super computer**
5. **Workstations**

## *» Micro Computer*

Microcomputer is at the lowest end of the computer range in terms of speed and storage capacity. Its CPU is a microprocessor. The first microcomputers were built of 8-bit microprocessor chips. The most common application of personal computers (PC) is in this category. The PC supports a number of input and output devices.

Microcomputers include (a) portable computers and (b) desktop computers.

**(a) Portable Computer**

Portable computer is a very small, easy to use microcomputer. The users can carry it wherever they go. This group includes personal digital assistant, pen-based computer, hand-held computer, notebook computer and laptop computer.

**(b) Personal Computer or Desktop Computer**

Personal computer is a microprocessor based, single user computer. The peripherals for personal computer include a keyboard and a mouse as input devices, monitor to display information and a hard disk for storage.



## *» Mini Computer*

Minicomputer is a medium sized computer that is costlier and more powerful than a microcomputer. It is in fact a scaled down version of mainframe computer. This can support up to a few hundred users at a time with multi-terminal, time-sharing system. They are mainly used as departmental computers in large and medium-sized organisations. They are also used in government departments, universities and R and D establishments.

### » Mainframe Computer

The earliest computers were callpd mainframes due to their size. The term is still used for the large computers of today. They have large storage capacities, very high speed of processing (compared to micros and minis) and can support a large number of terminals (Many hundreds to thousands) for use by a variety of users simultaneously. They are kept in air-conditioned environment in a special computer room. They are used by big companies, banks, government departments, etc. as their main computer.



### » Super computer

It is the fastest and the most expensive computer. This has extremely large storage capacities and computing speeds that are at least ten times faster than that of other computers. It can perform hundreds of millions of instructions per second. The super computer is used for specialised applications such as large-scale numerical problems in scientific and engineering disciplines. These include applications in electronics, petroleum engineering, weather forecasting, medicine and nuclear energy research.

## » *Workstations*

Workstation is a powerful computer which in terms of power is between personal computer and minicomputer. It has high resolution graphics monitor, large RAM and secondary storage. Although it is a standalone system, usually it forms part of a network and it uses Unix or Windows NT as operating system. Workstations are used for specialized applications such as desktop publishing, software development and engineering designs.



# 1.6 COMPONENTS OF COMPUTER SYSTEM

The computer hasthree parts.
1. Input Unit
2. Central Processing Unit (CPU)
3. Output Unit
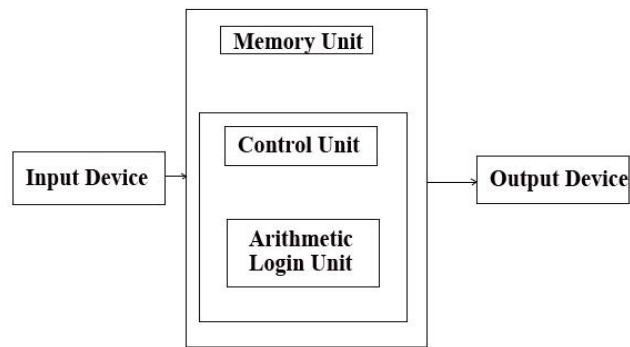
Any digital computer carries out five functions.

1. Takes data as input. (Input)
2. Stores the data/instructions in its memory and use them when required. ( Memory Unit )
3. Processes the data and converts it into useful information. ( ALU )
4. Controls all the above four steps (Control Unit)
5. Generates the output (Output)

### › *InputUnit*
This unit contains devices with the help of which we enter data into computer. This unit makes link between user and computer. An Input device accept data and instructions from the user and convert information or data in to a form which can be understood by the computer.

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

CPU  has following three components
• ALU(Arithmetic Logic Unit)
• Memory Unit
• Control Unit

• **ALU( Arithmetic Logic Unit )**
Function of arithmetic section is to perform arithmetic operations like addition, subtraction, multiplication and division and logical section perform logic operations such as comparing, selecting, matching and merging of data. The major operations performed by the ALU .
• **Memory Unit**
This unit can store instructions, data and intermediate results. This unit supplies information to the other units of the computer when needed.
• **Control Unit:**
The process of input, output, processing and storage is performed under the supervision of a unit called 'Control Unit'. It decides when to start receiving data, when to stop it, where to store data, etc. It takes care of step -by-step processing of all operations inside the computer.

### › *Output unit*
This is the process of producing results from the data for getting useful information.

## 1.7 INPUT DEVICES
This unit contains devices with the help of which we enter data into computer. This unit makes link between user and computer. An Input device accept data and instructions from the user and convert information or data in to a form which can be understood by the computer.

**Important input devices**
**1. Keyboard**
**2. Mouse**
**3. Light Pen**
**4. Trackball**
**5. Joystick**
**6. Scanners**
**7. Optical Mark Reader**
**8. Optical Character Reader**
**9. Barcode Reader**
**10. Magnetic Ink Character Recognition**
**11. Voice Recognition Systems**
**12. Digital Cameras**

### *Keyboard*
Keyboard is the most popular input device for direct entry of data and instructions into computer.The computer keyboard is very much like the electronic typewriter keyboard. But it has additional keys. now keyboards with 104 keys or 108 keys are also available for Windows and internet.



keyboard has following types of keys :
1**. Typing Keys-** digit keys (0-9) and letter keys (A-Z).
**2. Numeric Keypad**- set of 17 keys
**3. Function Keys-** The twelve function keys
**4. Control Keys**-These keys provide cursor and screen control. It includes four directional arrow keys. Control keys also include Home, End, Insert, Delete, Page Up, Page Down, Control(Ctrl), Alternate(Alt), Escape(Esc).
**5. Special Purpose Keys**- Enter, Shift, Caps Lock, Num Lock, Space bar, Tab, and Print Screen.

## Mouse

A mouse is a small hand-held 'point and click' device that is connected to the CPU through a cable. Douglas Engelbart invented mouse in 1963 at Stanford Research Institute. Xerox Corporation's Palo Alto Research Center enhanced its capabilities by adding analogue to digital conversion..It rolls on a small ball and has two or three buttons on the top. When you roll the mouse across a flat surface the screen censors the mouse in the direction of mouse movement. The cursor moves very fast with mouse giving you more freedom to work in any direction. It is easier and faster to move through a mouse.

There are three types of mouse:
1. Mechanical Mouse
2. Optomechanical Mouse
3. Optical Mouse



### 1. Mechanical Mouse
Mechanical Mouse has a trackball at its bottom. It can be rolled across a flat and smooth surface to control the position of the cursor on the screen. By pointing and clicking on icons and menu options displayed on the screen, it is easy for the user to control the computer with a mouse. Mechanical sensors within the mouse detect the direction the ball is rolling and move the screen pointer accordingly.

### 2.Optomechanical Mouse
The Optomechanical mouse is more or less the same as the mechanical mouse, but it uses optical sensors to detect motion of the ball.

### 3.Optical Mouse
Optical mouse uses a laser to detect the mouse movement. The mouse requires to be moved along a special mat with a grid so that the optical mechanism has a frame of reference. Optical mouse is more expensive than the other two.

## Light Pen

Light pen consists of a stylus connected by a cable to the computer terminal. When the stylus is brought into contact with the screen, a dot appears there on the screen. By moving the stylus on the screen, lines and curves can be drawn on the screen that can be stored and used as input.
An Light Pen utilizes a light-sensitive detector to select objects on a display screen. A light pen is similar to a mouse, except that with a light pen you can move the pointer and select objects on the display screen by directly pointing to the objects with the pen.

## *Trackball*

Trackball was originally built into the keyboard. Running a hand over the trackball made the cursor on the screen to move. The cursor is used to make selection from a menu displayed on the computer screen.In addition, you can place a trackball on any type of surface, including your lap. For both these reasons, trackballs are popular pointing devices for portable computers.



## *Joystick*

Joystick is a small vertical stick attached to a trackball for easier mechanical movements. It is used mainly in game programs.



## *Scanners*

Scanners are direct-entry input devices. As the data entry is automatic, the scanners ensure more accurate data entry. These scanners include optical scanners and magnetic ink character readers. The optical scanners use light for sensing input and they include OCR, OMR and Barcode reader.



## *Optical Mark Reader*

Optical mark reader (OMR) reads the presence or absence of a mark on a paper optically. Light is directed on to the paper and the reflected light is analysed for the detection of a mark. If a mark is there on the surface of the paper, that area sends back lesser light are to the OMR. It is

used to read multiple choice answers in a test and the data are transferred to a computer for processing.



## *Optical Character Reader*

Optical character reader (OCR) detects shape, and can identify characters. It can examine each character as if it were made up of a collection of minute spots. Once the whole character has been scanned, the pattern detected is matched against a set of patterns stored in the computer. The pattern that matches or nearly matches is taken to be the character read. Patterns that cannot be identified are rejected. It is used in mail sorting and credit card billing.



## *Barcode Reader*

Barcode is a set of small bars of varying thickness and spacing printed on the packages of products, on the back coverpages of books, tags etc. The barcode reader uses an optical scanner to read product code and converts it into electrical pulses. The device is connected to a computer and the information read is passed to the computer in digital form for automatic bill generation and updating of files. Thus, it is a direct data entry device and there is no need for an operator to key in sales transaction data.



## *Magnetic Ink Character Recognition*

Magnetic Ink Character Recognition (MICR) uses highly stylised character shapes printed in a special ink containing particles that can be magnetied. This ink induces a current in a reading circuit, which is proportional to the area of ink being scanned. The patterns of the varying

currents can be compared with and selected as bit patterns of the selected number e.g., the number on a cheque). The MICR reader can only identify characters. Banking industry uses this device for sorting of cheques. The MICR codes read from the cheques are transmitted to an online computer for sorting and processing automatically.



## *Voice Recognition Systems*

A special microphone is used to capture voice as input. It converts the voice into electrical pulses and then into digital signals for onward transmission to a computer for processing. A voice recognition system is provided with digital patterns of a limited vocabulary of words and phrases. The system operating in a training mode learns to recognize voice patterns by comparing the spoken input with the stored digital patterns. After identifying the input, the voice system generates appropriate code for the machine to accept input and operate. Voice recognition systems are very useful in offices for word processing. A manager can directly dictate letters and notes to a word processor through a speech recognition system. Similarly, the system can accept oral commands and execute them. These systems are yet to become popular.
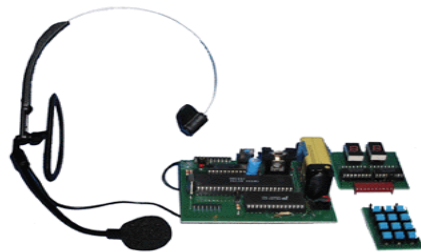


## *Digital Cameras*

Digital cameras are used to capture images and they can record the images on reusable floppy disks. Images are used with a digitiser for input to the computer. Once the image input is stored in computer, the image can be used in any application.



## 1.8 OUTPUT DEVICES

Output device displays result of the computer processing. A Output devices return processed data that is information, back to the user.

Some of the commonly used output devices are :
1. Monitor (Visual Display Unit)
2. Printers
3. Plotter
4. Speakers

## *Monitor (Visual Display Unit )*

Visual display units (VDUs) are television-like screens that provide the user-interface in the form of display of text, numbers and images. The VDUs may be monochrome or colour. The support of monochrome or colour and clarity of display depend on the type of video monitor and the video adapter installed in the microcomputer.
Two basic types of monitors are used with microcomputers :
1. Cathode Ray Tube (CRT)
2. Flat panel Displays (LCD,LED)

- **Cathode Ray Tube (CRT)**

CRT or Cathode Ray Tube Monitor is the typical monitor that you see on a desktop computer. It looks a lot like a television screen, and works the same way. This type uses a large vacuum tube, called cathode ray tube (CRT).



- **Flat panel Displays (LCD,LED)**

This type of monitors are also known as flat panel monitor. Most of these employ liquid crystal displays (LCDs) to render images. These days LCD monitor are very popular.

*Printer*

Printers are purely output devices. They produce hard copy output. Computer printers vary widely in their technologies and capabilities. They can be classified in a number of ways. First, they can be classified into three broad groups: character printers, line printers and page printers. The character printers print one character at a time. Dot matrix printer (DMP), daisy wheel printer, thermal printer and inkjet printer are the various types of character printers. Drum printer and chain printer are line printers. Laser printer and magnetic printer are page printers.

Some of the most commonly used printers are :
1. Laser Printer
2. Ink Jet Printer
3. Dot Matrix Printer
4. Line Printer

- **Laser Printer**

A laser printer produces high quality print that one normally finds in publishing. It is extremely fast and quiet. Moreover, the operation of a laser printer is easy with automatic paper loading and no smudging or messing up of ink ribbons. The fastest laser printer can print up to 200 pages per minute in monochrome (black and white) and up to 100 pages per minute in colour.

- **Ink-Jet Printer**

An ink-jet printer creates an image directly on paper by spraying ink through as many as 64 tiny nozzles. Although the image it produces is not generally quite as sharp as the output of a laser printer, the quality of ink-jet images is still high.
In general, ink-jet printer offers an excellent middle ground between dot matrix and laser printer. Like laser printer, an ink-jet printer is quiet and convenient, but not particularly fast. Typically, an ink-jet printer is more expensive than a dot-matrix printer, but costs only half as much as a laser printer.

- **Dot Matrix Printer**

The dot matrix printer was very popular at one point of time. It is a very versatile and inexpensive output device. In dot matrix printer the print head physically "hits" the paper through the ribbon and produces text (or images) by combinations of dots; hence the name dot matrix printer. Its speed is measured in characters per second (CPS). Although it is less expensive, it is louder, slower and produces lower print quality.

- **Line Printer**

A line printer is generally used with large computer systems to produce text based data processing reports. Line printers are high-speed printers with speeds ranging anywhere from 100 to about 3800 lines per minute. In the past, print quality on line printers was not high. Developments in technology are improving the print quality on line printers. These are in the cost range of lacs of Rupees.

*Plotter*

A plotter is a special kind of output device that like a printer produces images on paper but does so in a different way. Plotters are designed to produce large drawings or images, such as construction plans for buildings or blueprints for mechanical objects. A plotter can be connected to the port normally used by a printer.

## 2.6. NUMBER SYSTEM

The knowledge of number systems is essential for understanding of computers. The useful number systems discussed are :

1. *Binary Number System.*
2. *Octal Number System.*
3. *Decimal Number System.*
4. *Hexadecimal Number System.*

### 1. Binary Number System

The **Binary Number System,** as the name suggests, consists of two digits namely, 0 and 1. These binary digits are called **BITS.** Thus, the word **BIT** stands for either of the binary digits, namely 0 or 1. Since this system uses two digits only, it has the **base** or **radix** 2. It may be noted that the base digit namely 2, is not the fundamental or basic digit of the system. Thus, all the numbers in binary system are written with the help of these two digits namely, 0 and 1. The positional value or place value of each digit in a binary number is twice the positional value of the digit on its right. This number system is identical to decimal number system with the base replaced by 2. The binary numbers are usually written with the base indicated as a subscript on the least significant digit (LSD). *For example,*

$$(101101.1011)_2$$
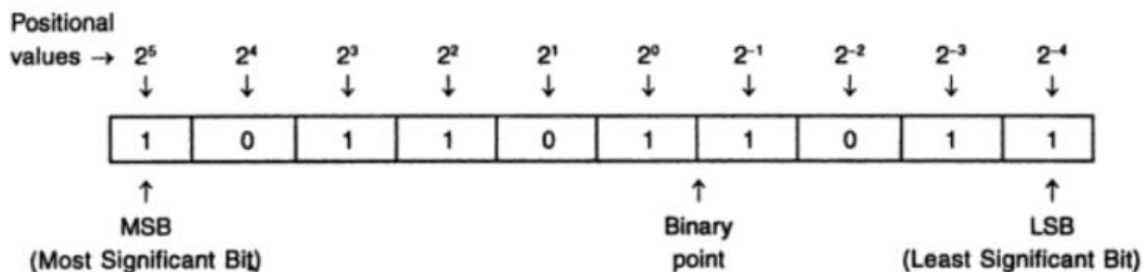
It can be represented as shown below :

Positional
values → $2^5$   $2^4$   $2^3$   $2^2$   $2^1$   $2^0$   $2^{-1}$   $2^{-2}$   $2^{-3}$   $2^{-4}$

| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|

↑ MSB (Most Significant Bit)     ↑ Binary point     ↑ LSB (Least Significant Bit)

**Fig. 1. Binary number shown with positional values.**

Here, the places to the left of the binary point are positive powers of 2 and places to the right are negative powers of 2.
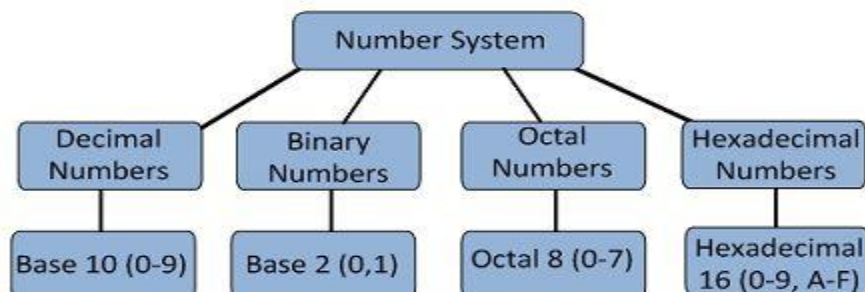
The commonly used terms in coding of data in computer terminology are :

**BIT (BInary digiT).** A binary digit is logical 0 or 1.

**Nibble.** A group of four bits (binary digits) is called a Nibble. It is useful in coding the numeric data to hexadecimal form.

**Byte.** A group of 8 bits make a byte. A byte is the smallest unit which can represent a data item or a character.

**Computer Word.** A computer word, like a byte, is a group of fixed number of bits which varies from computer to computer but is fixed for each computer. The number of bits in a computer word is known as the **word size** or **word length.**

| Number System | | | |
|---|---|---|---|
| Decimal Numbers | Binary Numbers | Octal Numbers | Hexadecimal Numbers |
| Base 10 (0-9) | Base 2 (0,1) | Octal 8 (0-7) | Hexadecimal 16 (0-9, A-F) |

## 2. Octal Number System

This number system has **base** or **radix** 8. The basic digits of this system are 0, 1, 2, 3, 4, 5, 6 and 7. It may be noted that the base 8 is not the basic digit of the system. It is commonly used as a shorthand way of expressing binary quantities. Also the numbers represented in octal number system can be used directly for input and output operations.

The octal number system is also a positional value system, wherein each octal digit has its own value or weight expressed as a power of 8. *For example,*

$$(157246.3174)_8$$
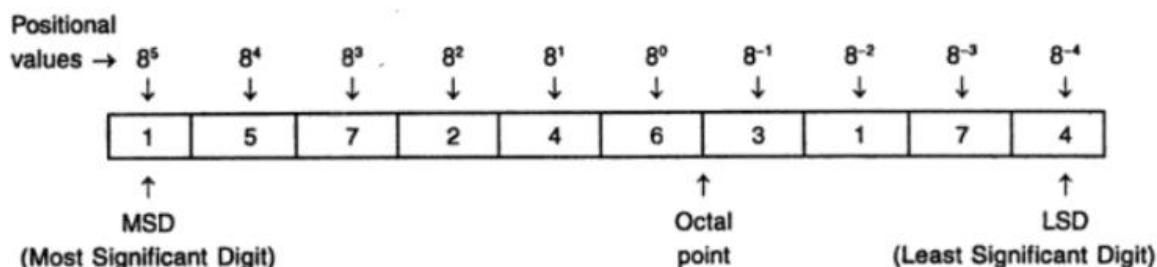
It can be represented as shown below :

Positional values → $8^5$ $8^4$ $8^3$ $8^2$ $8^1$ $8^0$ $8^{-1}$ $8^{-2}$ $8^{-3}$ $8^{-4}$

| 1 | 5 | 7 | 2 | 4 | 6 | 3 | 1 | 7 | 4 |
|---|---|---|---|---|---|---|---|---|---|

MSD (Most Significant Digit)     Octal point     LSD (Least Significant Digit)

**Fig. 2.** Octal number shown with positional values.

Here, the places to the left of the octal point are positive powers of 8 and places to the right are negative powers of 8.

## 3. Decimal Number System

The decimal number system consists of 10 digits namely 0 to 9. A number written using these digits is called a decimal number. For example, the numbers 12876, –1024, 58.74, +768 are decimal numbers. Apart from these digits, the decimal point and ± signs may also be used in writing decimal numbers. The **base** or **radix** of the number system is the number of digits used in it. Since the decimal number system consists of 10 digits, the base of this system is 10. In a number system the base is not the fundamental digit of the system because fundamental digits in this system are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
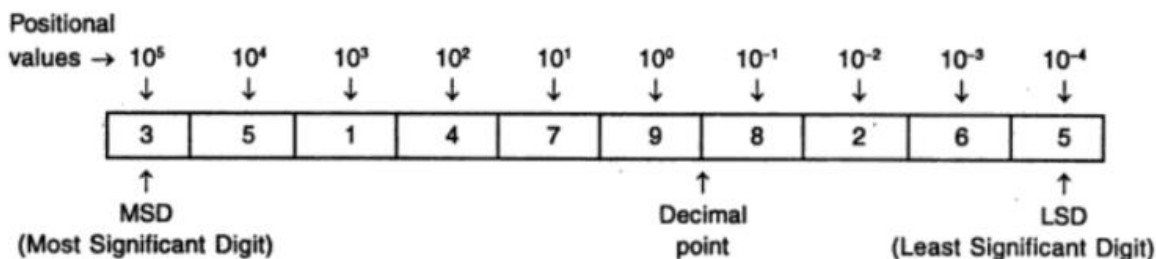
It can be represented as shown below :

Positional values → $10^5$ $10^4$ $10^3$ $10^2$ $10^1$ $10^0$ $10^{-1}$ $10^{-2}$ $10^{-3}$ $10^{-4}$

| 3 | 5 | 1 | 4 | 7 | 9 | 8 | 2 | 6 | 5 |
|---|---|---|---|---|---|---|---|---|---|

MSD (Most Significant Digit)     Decimal point     LSD (Least Significant Digit)

**Fig. 3.** Decimal number shown with positional values.

Here, the places to the left of the decimal point are positive powers of 10 and places to the right are negative powers of 10.

The part of the number before the decimal point is called **integral part** and the one after the decimal point is called the **fractional part.**

## 4. Hexadecimal Number System

The Hexadecimal Number System, popularly known as Hex System, has sixteen symbols and therefore has the **base** or **radix** as **16** or **H**. It is very well suited for big computers. The hexadecimal number system represents an information in the concise form. The sixteen symbols used in this system are :

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

The equivalence between hex-numbers (hexadecimal numbers) and decimal numbers is given below :

| Decimal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hexadecimal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |

Hexadecimal number system is also a positional value system, wherein each hexadecimal digit/letter has its own value or weight expressed as a power of 16. *For example,*

$$(6A9E83.C5BD)_{16}$$

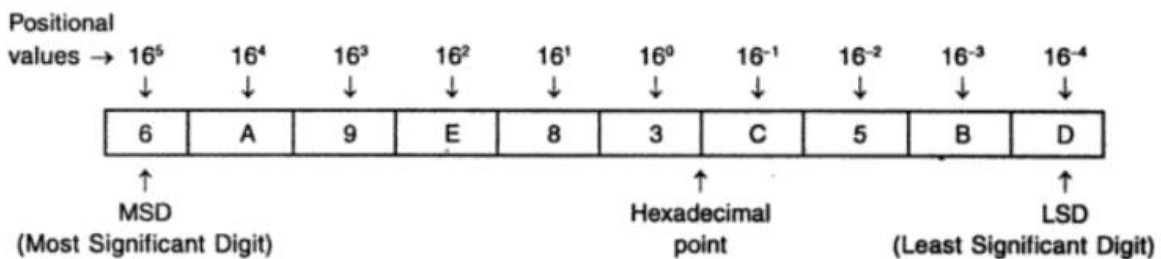It can be represented as shown below :



**Fig. 4.** Hexadecimal number shown with positional values.

Here, the places to the left of hexadecimal point are positive powers of 16 and places to the right are negative powers of 16.

The following table illustrates the relation between binary, octal, decimal and hexadecimal number systems :

| Decimal | Binary | Octal | Hexadecimal |
|---|---|---|---|
| 0 | 0000 | 0 | 0 |
| 1 | 0001 | 1 | 1 |
| 2 | 0010 | 2 | 2 |
| 3 | 0011 | 3 | 3 |
| 4 | 0100 | 4 | 4 |
| 5 | 0101 | 5 | 5 |
| 6 | 0110 | 6 | 6 |
| 7 | 0111 | 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 |

# Conversion between two different number systems

The decimal number system is known as **International System** of numbers. This base (base 10) was used initially perhaps for the reason that man has 10 fingers. However, this system is unsuitable for computers because a computer uses electrical and electronical components which can exist only in two states. Hence, for computers the binary number system is required. But, the binary number system at the moment is indispensable for computers as it suffers from the defect of expansion. For example, a number in decimal system requiring only one digit for its representation may require more than one bits in binary form.

To overcome this problem various other number systems such as Octal (base 8) and Hexadecimal (base 16 or H) were developed. A base greater than 10 is preferred because it will require even lesser number of digits. The choices of bases 8 and 16 are useful because of their being multiple of two.

## Conversion from Binary to Decimal

A binary number can be converted to its decimal equivalent by adding the weights of the various positions in it which have a 1.

**Example 1.** *Find the decimal equivalent of the following binary numbers :*
(i) *10110* (ii) *101011* (iii) *11011100.*

**Solution :**

(i)
$$(10110)_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$
$$= 16 + 0 + 4 + 2 + 0$$
$$= (22)_{10}.$$

(ii)
$$(101011)_2 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$
$$= 32 + 0 + 8 + 0 + 2 + 1$$
$$= (43)_{10}$$
$$= 43.$$

(iii)
$$(11011100)_2 = 1 \times 2^7 + 1 \times 2^6 + 0 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$$
$$= 128 + 64 + 0 + 16 + 8 + 4 + 0 + 0$$
$$= (220)_{10}$$
$$= 220.$$

**Example 2.** *Convert the following binary fractions to their decimal equivalents :*
(i) *(0.111)₂*

**Solution :**

(i)
$$(0.111)_2 = 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3}$$
$$= 1/2 + 1/4 + 1/8$$
$$= 0.5 + 0.25 + 0.125$$
$$= (0.875)_{10}$$
$$= 0.875$$

$$\therefore \qquad (0.111)_2 = (0.875)_{10}$$