FUNDAMENTALS

OF COMPUTERS

AND

INFORMATION TECHOLOGY

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1. INTRODUCTION TO COMPUTER

Computers are an integral part of our lives. Wherever we are—sitting in our homes, working in the office, driving on roads, sitting in a movie hall, staying in a hotel, etc.—our lives are directly or indirectly affected by the computers. In this era of information, we are dependent on the storage, flow and processing of data and information, which can only be possible with the help of computers. The purpose of this chapter is to introduce you to the "computer".

1.1 INTRODUCTION

Nowadays, computers are an integral part of our lives. They are used for the reservation of tickets for airplanes and railways, payment of telephone and electricity bills, deposit and withdrawal of money from banks, processing of business data, forecasting of weather conditions, diagnosis of diseases, searching for information on the Internet, etc. Computers are also used extensively in schools, universities, organizations, music industry, movie industry, scientific research, law firms, fashion industry, etc.

The term computer is derived from the word compute. The word compute means to calculate. A computer is an electronic machine that accepts data from the user, processes the data by performing calculations and operations on it, and generates the desired output results. Computer performs both simple and complex operations, with speed and accuracy.

This chapter discusses the history and evolution of computer, the concept of input-process-output and the characteristics of computer. This chapter also discusses the classification of digital computers based on their size and type, and the application of computer in different domain areas.

1.2 DIGITAL AND ANALOG COMPUTERS

A digital computer uses distinct values to represent the data internally. All information is represented using the digits Os and 1s. The computers that we use at our homes and offices are digital computers.

Analog computer is another kind of a computer that represents data as variable across a continuous range of values. The earliest computers were analog computers. Analog computers are used for measuring of parameters that vary continuously in real time, such as temperature, pressure and voltage. Analog computers may be more flexible but generally less precise than digital computers. Slide rule is an example of an analog computer.

This book deals only with the digital computer and uses the term computer for them.

1.3 CHARACTERISTICS OF COMPUTER

Speed, accuracy, diligence, storage capability and versatility are some of the key characteristics of a computer. A brief overview of these characteristics are:

- **Speed** The computer can process data very fast, at the rate of millions of instructions per second. Some calculations that would have taken hours and days to complete otherwise, can be completed in a few seconds using the computer. For example, calculation and generation of salary slips of thousands of employees of an organization, weather forecasting that requires analysis of a large amount of data related to temperature, pressure and humidity of various places, etc.

- **Accuracy** Computer provides a high degree of accuracy. For example, the computer can accurately give the result of division of any two numbers up to 10 decimal places.

- **Diligence** When used for a longer period of time, the computer does not get tired or fatigued. It can perform long and complex calculations with the same speed and accuracy from the start till the end.

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- **Storage Capability** Large volumes of data and information can be stored in the computer and also retrieved whenever required. A limited amount of data can be stored, temporarily, in the primary memory. Secondary storage devices like floppy disk and compact disk can store a large amount of data permanently.

- **Versatility** Computer is versatile in nature. It can perform different types of tasks with the same ease. At one moment you can use the computer to prepare a letter document and in the next moment you may play music or print a document.

Computers have several limitations too. Computer can only perform tasks that it has been programmed to do. Computer cannot do any work without instructions from the user. It executes instructions as specified by the user and does not take its own decisions.

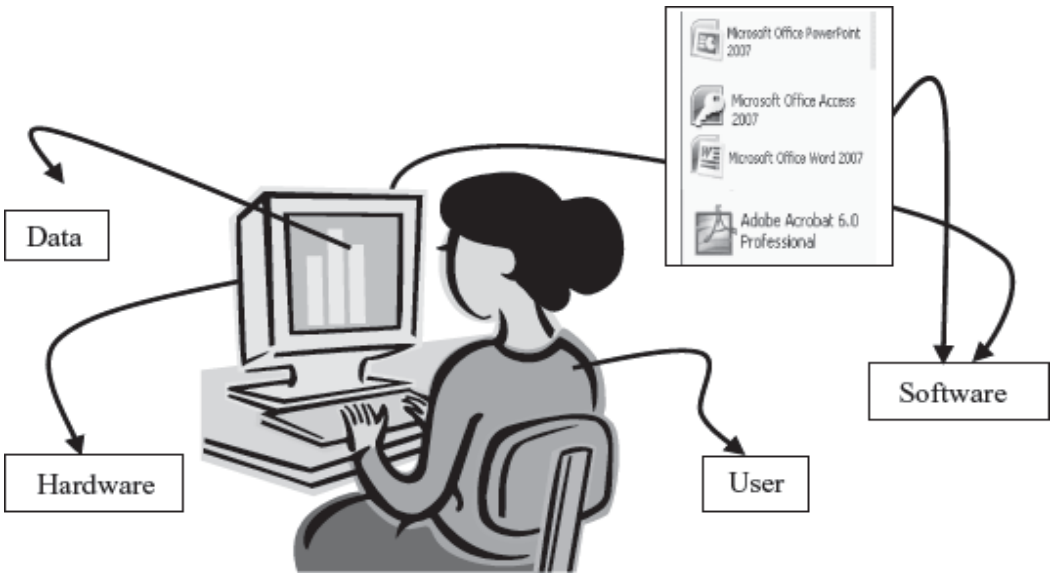
SUMMARY

- ✓ Computer is an electronic device which accepts data as input, performs processing on the data, and gives the desired output. A computer may be analog or digital computer.

- ✓ Speed, accuracy, diligence, storage capability and versatility are the main characteristics of computer.

2. THE COMPUTER SYSTEM

Computers is an electronic device that accepts data as input, processes the input data by performing mathematical and logical operations on it, and gives the desired output. The computer system consists of four parts•(1) Hardware, (2) Software, (3) Data, and (4) Users. The parts of computer system are shown in Figure.



Computers, in simple words, are machines that perform a set of functions according to their users' directions. Going by this definition, several electronic devices, from laptops to calculators, are computers.

A computer comprises of some basic elements. These include hardware, software, programs, data and connectivity. No computer can function in the absence of these elements. Apart from these elements, a computer system comprises of three basic components. These components are responsible for making computers actually function. Let's take a look at them in detail.

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2.1 Components of Computer Hardware

When we talk of computer hardware, the three related terms that require introduction are—computer architecture, computer organization and computer design. Computer architecture refers to the structure and behavior of the computer. It includes the specifications of the components, for example, instruction format, instruction set and techniques for addressing memory, and how they connect to the other components. Given the components, computer organization focuses on the organizational structure. It deals with how the hardware components operate and the way they are connected to form the computer. Given the system specifications, computer design focuses on the hardware to be used and the interconnection of parts. Different kinds of computer, such as a PC or a mainframe computer may have different organization; however, basic organization of the computer remains the same.

A computer consists of three main components:

1) Input/Output (I/O) Unit.
2) Central Processing Unit (CPU).
3) Memory Unit.

The computer user interacts with the computer via the I/O unit. The purpose of I/O unit is to provide data and instructions as input to the computer and to present relevant information as output from the computer. CPU controls the operations of the computer and processes the received input to generate the relevant output. The memory unit stores the instructions and the data during the input activity, to make instructions readily available to CPU during processing. It also stores the processed output. This section discusses the hardware components of the computer and the interaction between them.

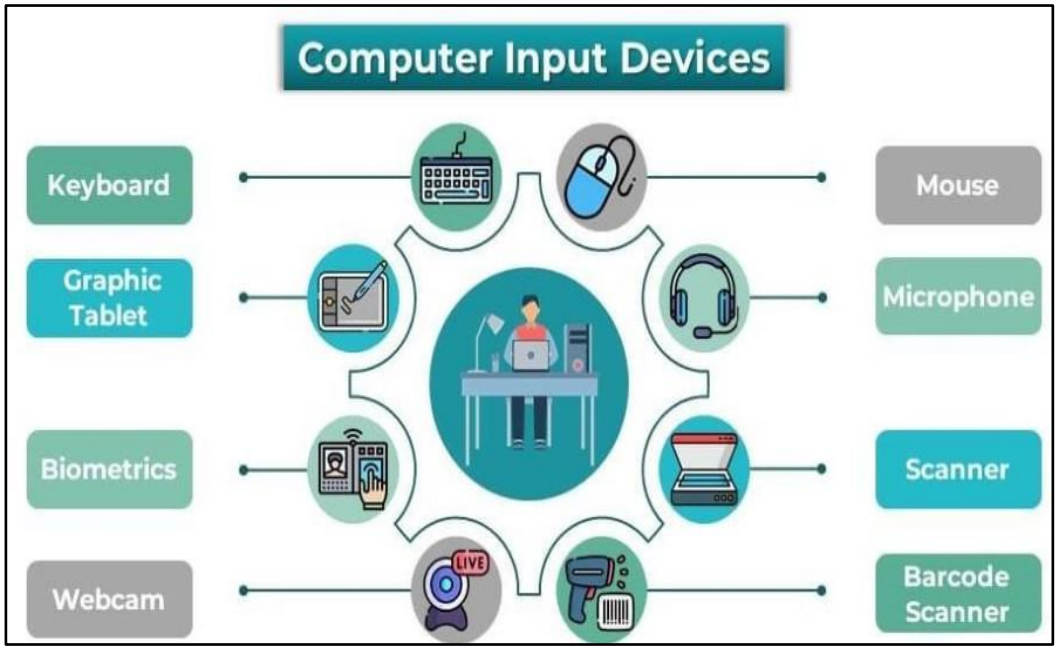
2.1.1 INPUT-OUTPUT UNIT

An I/O unit is a component of computer. The I/O unit is composed of two parts—input unit and output unit. The input unit is responsible for providing input to the computer and the output unit is for receiving output from the computer.

Input Unit

- The input unit gets the data and programs from various input devices and makes them available for processing to other units of the computer.
- The input data is provided through input devices, such as—keyboard, mouse, trackball and joystick. Input data can also be provided by scanning images, voice recording, video recording, etc.
- Irrespective of the kind of input data provided to a computer, all input devices must translate the input data into a form that is understandable by the computer, i.e., in machine readable form. The transformation of the input data to machine readable form is done by the input interface of input device.

In brief, the input unit accepts input data from the user via input device, transforms the input data in computer acceptable form using input interface for the input device and provides the transformed input data for processing.



Input devices allow users and other applications to input data into the computer, for processing. The data input to a computer can be in the form of text, audio, video, etc. The data is entered manually by the user or with minimal user

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intervention. An input device is a hardware device that transfers data to a computer system and allows us to control it.

WHAT IS AN INPUT DEVICE?

The electromagnetic devices that accept data or a set of instructions from the outside world and then translate that data into machine-readable and understandable form are known as input devices. Computer input devices serve as an interface between the outside world and the computer for proper communication. When the users enter data using various input devices, the data can be saved in computer memory for further processing and preparation. Using the output devices, the intended and calculated results can be acquired when the processing and handling are completed. An input device transmits data to a computer and allows you to communicate with it and control it.

Different Types of Input Devices

Keyboard

For entering data into a computer, the keyboard is the most common and commonly used input device. It contains various keys for entering letters, numbers, and characters. Although there are some additional keys for completing various activities, the keyboard layout is identical to that of a standard typewriter. It is generally available in two different sizes 84 keys or 101/102 keys and for Windows and the Internet, it is also available with 104 keys or 108 keys. It is connected to a computer system with the help of a USB or a Bluetooth device.

The keys on the keyboard are:

- **Numeric Keys:** These keys are used to enter numeric data and move the cursor. It is typically made up of 17 keys.
- **Keyboard Shortcuts:** These keys include the letter keys (A-Z) and the number keys (09).
- **Control Keys:** The pointer and the screen are controlled by these keys. It comes with four directional arrow keys. Control keys include Home, End, Insert, Alternate(Alt), Delete, Control(Ctrl), and Escape.
- **Special Keys:** Enter, Shift, Caps Lock, NumLk, Tab, and Print Screen are some of the special function keys on the keyboard.
- **Function Keys:** The 12 keys from F1 to F12 are on the topmost row of the keyboard.

Generally, the keyboard is of three types:

- QWERTY Keyboard
- AZERTY Keyboard
- DVORAK Keyboard

Characteristics of Keyboard:

- ✓ The keyboard has various functions keys for a different purpose
- ✓ Instead of using the mouse, we can utilize the arrow keys on the keyboard to do the same purpose as the mouse.
- ✓ The main keyboard, cursor keys, numeric keypad, and function keys are the four primary components of a keyboard.
- ✓ Keyboards are more affordable.

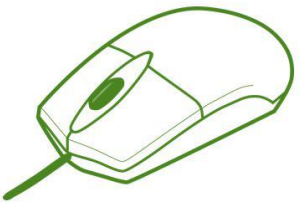
Mouse

The mouse is the most used pointing device. While clicking and dragging, the mouse moves a little cursor across the screen. If you let off of the mouse, the

cursor will come to a halt. You must move the mouse for the computer to move; it will not move on its own. As a result, it's a device that accepts input. Or we can say that a mouse is an input device that allows you to control the coordinates and movement of the on-screen cursor/pointer by moving the mouse on a flat surface. The left mouse button can be used to pick or move items, while the right mouse button displays additional menus when clicked. It was invented in 1963 by Douglas C. Engelbart.

Generally, the mouse is of four types:

- Trackball Mouse
- Mechanical Mouse
- Optical Mouse
- Wireless Mouse



Characteristics of the mouse:

- ✓ A mouse is used to move the cursor on the screen in the desired direction.
- ✓ A mouse allows users to choose files, folders, or multiple files or text or, all at once.
- ✓ Hover over any object with the mouse pointer.
- ✓ A mouse can be used to open a file, folder, etc. You must first move your pointer to a file, folder, and then double-click on it to open or execute.

Joystick

A pointing device used to move the cursor around the screen is the joystick. Both the bottom and top ends of the stick have a spherical ball affixed to them. A socket contains the lower spherical ball. You can adjust the joystick in all directions. Trackballs became quite popular in laptops and PCs since they fit neatly inside the case and take up less room when in use. They are

more precise and long-lasting than a mouse, which is why they are still utilized. It is invented by C.B.Mirick.

Characteristics of Joystick:

- ✓ It's utilized to regulate the cursor's position across a display screen.
- ✓ It's utilized in computer games to move the characters and symbols around.
- ✓ It commonly features one or more push buttons, the condition of which can be controlled by the computer as well.

Light Pen

A light pen is a pointing device that has the appearance of a pen. It can be used to draw on the monitor screen or to pick a menu item. In a small tube, a photocell and an optical system are housed. The photocell sensor element determines the screen location and sends a signal to the CPU when the tip of a light pen is moved across a monitor screen while the pen button is pressed.

Characteristics of the light pen:

- ✓ When drawing graphics, a light pen comes in very handy.
- ✓ Objects on the display screen are selected with a light pen.

Scanner

A scanner is a type of input device that works in the same way as a photocopier. It's used when there's data on paper that needs to be transferred to the computer's hard disc for further processing. The scanner collects images from the source and translates them to a digital version that can be saved on the hard disks. These graphics can be changed before they are printed.

Generally, the scanner is of five types:

- Flatbed Scanner
- Handheld Scanner
- Sheetfed Scanner
- Drum Scanner
- Photo Scanner

Characteristics of Scanner:

- ✓ You can scan film negatives via a scanner if there is a transparent media adaptor.
- ✓ A scanner may also scan low-quality or non-standard-weight paper.
- ✓ The scanners are adaptable, allowing you to scan a wide range of items regardless of their size. You can scan small items as well as large documents if you can locate them.

OCR

OCR stands for Optical Character Recognition in its full form. OCR is a computer reading technique that reads numbers, characters, and symbols. OCR is a technique for recognizing text in documents that have been scanned into digital form. Optical character recognition (OCR) refers to a device that reads printed text. Character by character, OCR scans the text, converts it to a machine-readable code, and saves it into the memory of the system. OCR also functions as a scanner, scanning documents, photos, images, and handwritten text and storing the information in memory, which may then be compared to previously stored data.

Characteristics of OCR:

- ✓ The technology offers a complete solution for form processing and document capture.

- ✓ It has capabilities for defining shapes, scanning, image pre-processing, and identification.

Barcode Reader

A bar code reader is a device that reads bar-coded data (data that is represented by light and dark lines). To label things, number books, and so on, bar-coded data is often utilized. It could be a standalone scanner or a component of one. A barcode reader is a device that reads barcodes and extracts data from them. The code bar is used to read the bar code printed on any goods. By impacting light beams on barcode lines, a barcode reader identifies existing data in barcodes.

Characteristics of Barcode Reader:

- ✓ When a card is inserted, auto-start barcode scanners begin scanning immediately.
- ✓ Reading indicators give the user confirms that the card has been swiped correctly.
- ✓ It's simple to use, simply hold your phone up to the code and scan it.

Web Camera

A webcam is an input device since it records a video image of the scene in front of it. It can either be incorporated inside the computer (for example, a laptop) or connected via USB. A webcam is a small digital video camera that is connected to a computer. Because it can capture pictures and record video, it's also known as a web camera.

Characteristics of Web Camera:

- ✓ Webcams are used to allow individuals to see one other while chatting online. This is formally referred to as 'teleconferencing'.
- ✓ Because webcams can take a picture only if movement is detected in the scene in front of them, they are commonly utilized in burglar alarms and other security systems.

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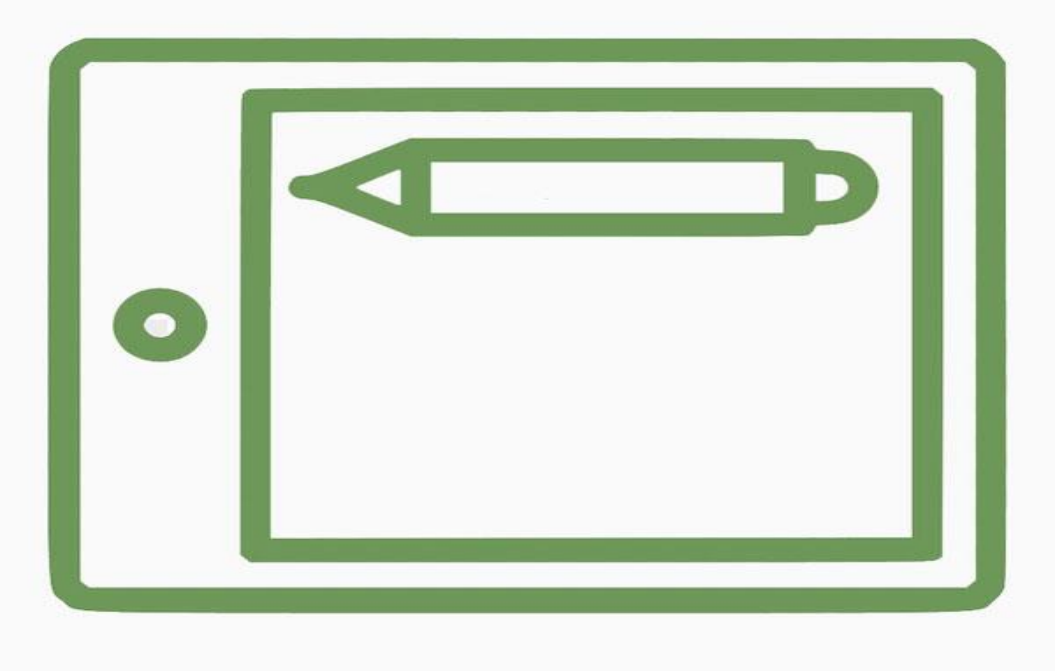
- ✓ Hundreds of webcams can be found all around the world, each pointing to a fascinating scene such as the exterior view of a facility in the Arctic or Niagara Falls. The webcam is connected to a computer that regularly sends an image to an internet server. After that, people connect to the server to view the most recent image.

Graphic Tablet

A graphics tablet, also known as a digitizing tablet, is a computer input device that allows users to draw drawings and graphics by hand, much like they would with a pencil and paper. A graphics tablet is a flat surface on which the user can draw a picture with the help of an attached stylus, which is a pen-like drawing device.

Characteristics of a Graphics Tablet:

- ✓ The graphics tablet is a pressure-sensitive tablet that is controlled by a pen.
- ✓ Drawing, writing, inserting, etc. can be done with the pen.
- ✓ It provides more precision and the ability to monitor (than a touchscreen).



Digital Camera

Digital camera is a device that takes photographs as input. Images are saved on memory cards as data. It comes with an LCD display that allows users to view and review photographs. A digital camera contains photosensors that record the light that enters into the camera lens. So, when the light strikes the photosensors, they return the electric current and this electric current is used to create images.

Characteristics of Digital Camera:

- ✓ Users can immediately examine images and movies on the LCD screen.
- ✓ All the photos can be stored in the storage device.
- ✓ Users can select and choose the images they want to develop.
- ✓ Easily portable & takes less space.

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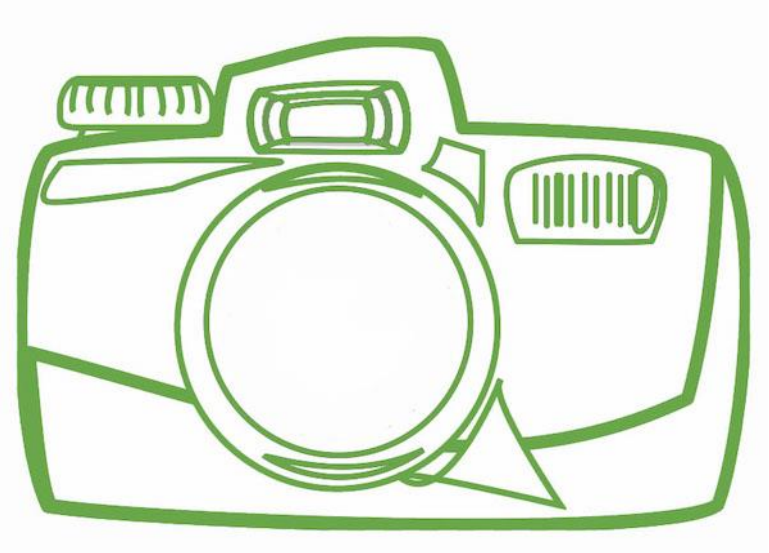

Output Unit

- The output unit gets the processed data from the computer and sends it to output devices to make them available to the user of computer.
- The output data is provided through output devices like display screen, printer, plotter and speaker.
- The processed data sent to the output device is in a machine understandable form. This processed data is converted to human readable form by the output interface of output device.

In brief, the output unit accepts output data from computer via output device, transforms the output information to human readable form using the output interface of output device and provides the transformed output to user.

In addition to input devices and output devices, some devices function as both input and output devices. The I/O devices provide the input to computer as well as get output from computer. The I/O devices are used by both the input unit and the output unit. Hard disk drive, floppy disk drive, optical disk drives are examples of I/O devices.

Output Devices are those devices which show us the result after giving the input data to a computer system. Output can be in different forms like image, graphic audio, video, etc.

What is an Output Device?

Any peripheral that accepts data from a computer and prints, projects, or reproduces it is known as an output device. The output may be audio, video, hard copy – printed paper, etc. Output devices convert the computer data to human understandable form. We give input to the computer using input devices and the computer performs operations on the data and displays the output to the user using the output device.

How Does an Output Device Work?

In order to show the output, an output device uses a signal it receives from the computer to accomplish a task. An output device's fundamental operation is listed below as an illustration.

- If you enter 'Hi Geeks' on a computer keyboard (input device), the computer receives the signal.
- Once the input has been processed by the computer, an output device—a monitor—is signalled.
- The display (output) of the 'Hi Geeks' on the screen occurs once the monitor receives the signal.
- Another example of an output device is a printer, which might print that 'Hi Geeks' if it were supported.

If the computer was working and had no output device attached, you could still type 'Hi Geeks' on the keyboard and it would still be processed. Without an output device, you couldn't see what happened or verify the input, though.

Different Types of Output Devices

The various output devices are as below:

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1. Monitor

A computer's principal output device is a monitor, often known as a visual display unit (VDU). It displays the processed data like text, images, videos, audios, etc. It makes images by arranging microscopic dots in a rectangular pattern, known as pixels. The sharpness of an image is determined by the number of pixels. There are two types of monitor viewing screens:

- **Cathode-Ray Tube (CRT):** This type of monitor is based on a cathode ray tube. In which the cathode ray tube generates a beam of electrons with the help of electron guns they strike on the inner surface of phosphorescent of the screen to generate images. The CRT monitor holds millions of phosphorus dotes in three different colors, i.e., red, blue, and green. These dots glow when the beam struck on them and create an image. The main parts of the CRT monitor are the electron gun, fluorescent screen, glass envelope, deflection plate assembly, and base.

- **Display on a Flat Panel Monitor with a Cathode-Ray Tube (CRT):** A flat-panel display is a type of video display with less volume, weight, and power consumption than a CRT. They can be put on the wrist or hang on the wall. Calculators, video games, monitors, laptop, and graphical displays all use flat-panel displays.

- **Plasma Monitor:** It is also a flat panel display but it is based on plasma display technology. In a plasma monitor, a small cell is present in between two glass surfaces and these cells contain a solution of noble gases and mercury. So when the electricity supply on the gas present in the cell converts into plasma and produces UV light that creates an image. It is much better than an LCD monitor. The resolution of this monitor is also high up to 1920 x 1920. It has a good contrast ratio, high refresh rate, etc.

Characteristics of Monitor:

- **Resolution pixels:** Pixels are the smallest element of any image
- **Size:** The size of the monitor is diagonal measurement of a desktop screen is typically 14 to 25 inches.
- **Refresh Rate:** Total number of times per second that an image on a display is repainted or refreshed.

2. Printer

Printers are information output devices that allow you to print data on paper. Or in other words, it is an output device that creates a hard copy of the processed data or information. Printers are divided into two categories:

- **Impact Printer:** In impact printers, characters are printed on the ribbon, which is then smashed on the paper. Or we can say that such type of printer uses a print head or hammer to print the data on the paper. Here to print the paper the hammer or print head strikes an ink ribbon against the paper and the character starts printing. Some of the types of impact printers are:
    - ✓ Dot matrix printer
    - ✓ Daisy wheel printer
    - ✓ Line printer
    - ✓ Chain printer
- **Impact printers have the following characteristics:**
    - ✓ Extremely low consumable costs.
    - ✓ Fairly noisy
    - ✓ It's perfect for large-scale printing because of its inexpensive cost.
    - ✓ Physical contact with the paper is required to form an image.
- **Non-Impact Printers:** Non-impact printers print characters without the use of a ribbon. These printers are often known as page printers because they print a full page at a time. Some of the types of non-impact printers are:
    - ✓ Laser printer

- ✓ Inkjet printer

- **Non-impact printers have the following characteristics:**
  - ✓ Quicker.
  - ✓ They don't produce much noise.
  - ✓ Superior quality.
  - ✓ Supports a wide range of fonts and character sizes.

3. Plotter

A plotter is a device that prints high-quality graphics in a variety of color formats. It works in a similar way to a printer, although it has more advanced features. It is used to print large maps, architectural drawings, large-format printing, and create pictures, 3D postcards, advertising signs, charts, and various designs of the internal structure of building machines, as well as create pictures, 3D postcards, advertising signs, charts, and various designs of the internal structure of building machines.

Characteristics of Plotter:

- ✓ Large size prints can be taken via plotters.
- ✓ It is slow and expensive.

4. Projector

A projector is a device that allows users to project their output onto a large area, such as a screen or a wall. It can be used to project the output of a computer and other devices onto a screen. It magnifies texts, photos, and movies using light and lenses. As a result, it's an excellent output device for giving presentations or teaching big groups of people.

Characteristics of Projector:

- ✓ They are lightweight, and one person can easily take them out of the box, connect them, and hang an image on the wall.
- ✓ Projectors can be the most cost-effective option for large-screen video in your home.
- ✓ A small projector mounted on a back shelf or bookcase, or mounted on the ceiling, takes up no area on the floor. It is barely visible when it is not in use.

5. Speakers

Speakers are connected to computers to allow sound to be output. For the working of speakers, sound cards are required. From simple two-speaker output devices to surround-sound multi-channel sets, speakers come in a variety of shapes and sizes. They take audio input from the computer's sound card and output sound waves as audio output.

Characteristics of Speakers:

- ✓ Speakers are available in a wide range of qualities and prices.
- ✓ Small, plastic computer speakers with low sound quality are often included with computer systems.

6. Headphones

To hear the sound, use earbuds with your computer, laptop, or smartphone. It enables you to hear the sound without causing any inconvenience to others. To translate electronic signals into sounds without causing inconvenience to others. They can be wired or wireless and can be connected to computers, laptops, mobile phones, etc. They are connected with the devices via Bluetooth.

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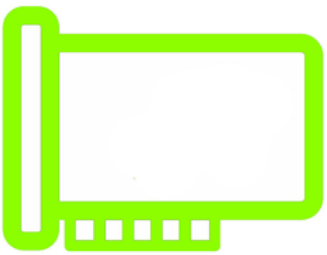
Characteristics of Headphones:

- ✓ Stereo phones and headsets are other names for them.
- ✓ Earphones or earbuds are the names for the in-ear variants.
- ✓ The term headset denotes a combination of headphones and a microphone used for two-way communication, such as using a telephone.

7. Sound Card

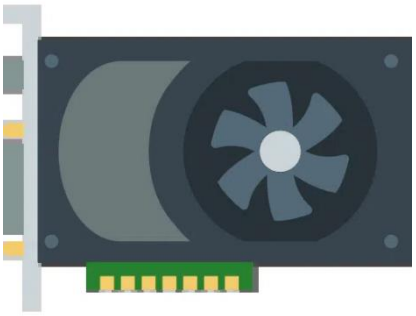
Sound cards are computer output devices that are inserted into the computer. A sound card, either external or internal, is required to produce sound on any computer (built-in). An external sound card enables for better overall sound generation and is required for wide and clear sound recording, as well as sound without noise and interference.



Characteristics of Sound Card:

- ✓ To listen speakers or headphones, to play games, watch movies, listen to music, or use audio and video conferencing, we use an internal sound card.
- ✓ Frequency is a sound card parameter that represents the number of signals the card processes per unit of time. The frequency is expressed in hertz. The frequency of most sound cards is 96 or 192 kHz.
- ✓ Synthesizers and a variety of electronic musical instruments, such as drums and keyboards, can be connected to your computer using a sound card with standard musical instrument digital interface (MIDI) connections.

8. Video Card



An extension card via which a computer can transfer graphical data to a video display device like a TV, or monitor. It processes photos and video, as well as other functions that the CPU generally does. As they have a good processing capability and video RAM, Gamers utilize video cards.

Characteristics of Video Card:

- ✓ Heat sinks are required for video cards with high performance as they generate a lot of heat.
- ✓ Also known as graphics card and require software installation in addition to the hardware.
- ✓ When working with huge files, video cards supply a significant quantity of video-only memory that frees up CPU resources, allowing the system to run more effectively.

9. Speech Synthesizer

A speech synthesizer is a computerized device that takes in data, interprets it, and generates audible words. It might be a computer card, a box connected by a cable, or software that works with the computer's sound card.

Characteristics of speech synthesizer:

- ✓ Any text, predetermined input can be translated into audible speech.
- ✓ For people who are unable to talk or have impaired vision, it can provide digital verbal communication.
- ✓ It takes in data, interprets it, and generates sound output.

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10. GPS

The Global Positioning System (GPS) is a radio-based satellite navigation system that uses radio signals to pinpoint a specific position. The sender sends a radio signal to satellites, which collect data such as time, location, speed, and other variables and deliver it to the reception computer for analysis. Because this processed data can be evaluated to obtain information, it is considered as an output device.

Characteristics of GPS:

- ✓ GPS satellites constantly communicate their position and time.
- ✓ Solar storms, high storm cover, and other factors impair GPS equipment.
- ✓ The Global Positioning System (GPS) is based on the mathematical idea of trilateration.
- ✓ The GPS works independently of telephonic or internet reception and does not need the user to send any data, however, to improve accuracy both technologies can be used.

Both the Input and Output Devices of the Computer

There are so many devices that contain the characteristics of both input and output. They can perform both operations as they receive data and provide results. Some of them are mentioned below.

USB Drive

USB Drive is one of the devices which perform both input and output operations as a USB Drive helps in receiving data from a device and sending it to other devices.

Modem

Modems are one of the important devices that helps in transmitting data using telephonic lines.

CD and DVD

CD and DVD are the most common device that helps in saving data from one computer in a particular format and send data to other devices which works as an input device to the computer.

Headset

The headset consists of a speaker and microphone where a speaker is an output device and a microphone works as an input device.

Facsimile

A facsimile is a fax machine that consists of a scanner and printer, where the scanner works as an input device and the printer works as an output device.

2.1.2 Central Processing Unit (CPU).

The full form of **CPU** is **Central Processing Unit**. It is a brain of the computer. All types of data processing operations and all the important functions of a computer are performed by the CPU. It helps input and output devices to communicate with each other and perform their respective operations. It also stores data which is input, intermediate results in between processing, and instructions.

A Central Processing Unit is the most important component of a computer system. A CPU is a hardware that performs data input/output, processing and storage functions for a computer system. A CPU can be installed into a CPU socket. These sockets are generally located on the motherboard. CPU can perform various data processing operations. CPU can store data, instructions, programs, and intermediate results.

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History of CPU

Since 1823, when Baron Jons Jakob Berzelius discovered silicon, which is still the primary component used in the manufacture of CPUs today, the history of the CPU has experienced numerous significant turning points. The first transistor was created by John Bardeen, Walter Brattain, and William Shockley in December 1947. in 1958, the first working integrated circuit was built by Robert Noyce and Jack Kilby.

The Intel 4004 was the company's first microprocessor, which it unveiled in 1971. Ted Hoff's assistance was needed for this. When Intel released its 8008 CPU in 1972, Intel 8086 in 1976, and Intel 8088 in June 1979, it contributed to yet another win. The Motorola 68000, a 16/32-bit processor, was also released in 1979. The Sun also unveiled the SPARC CPU in 1987. AMD unveiled the AM386 CPU series in March 1991.

In January 1999, Intel introduced the Celeron 366 MHZ and 400 MHz processors. AMD back in April 2005 with it's first dual-core processor. Intel also introduced the Core 2 Dual processor in 2006. Intel released the first Core i5 desktop processor with four cores in September 2009.

In January 2010, Intel released other processors like Core 2 Quad processor Q9500, the first Core i3 and i5 mobile processors, first Core i3 and i5 desktop processors.

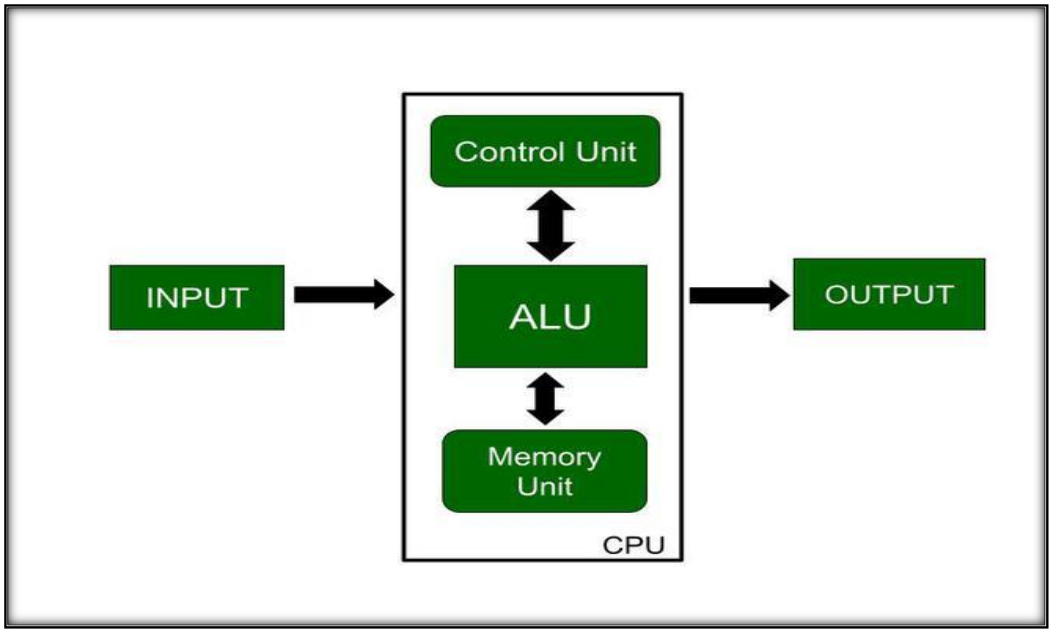
In June 2017, Intel released Core i9 desktop processor, and Intel introduced its first Core i9 mobile processor In April 2018.

Different Parts of CPU

Now, the CPU consists of 3 major units, which are:

1. Memory or Storage Unit
2. Control Unit
3. ALU(Arithmetic Logic Unit)

Let us now look at the block diagram of the computer:



Here, in this diagram, the three major components are also shown. So, let us discuss these major components:

1. **Memory or Storage Unit**

As the name suggests this unit can store instructions, data, and intermediate results. The memory unit is responsible for transferring information to other units of the computer when needed. It is also known as an internal storage unit or the main memory or the primary storage or Random Access Memory (RAM) as all these are storage devices.

Its size affects speed, power, and performance. There are two types of memory in the computer, which are primary memory and secondary memory. Some main functions of memory units are listed below:

- ✓ Data and instructions are stored in memory units which are required for processing.
- ✓ It also stores the intermediate results of any calculation or task when they are in process.
- ✓ The final results of processing are stored in the memory units before these results are released to an output device for giving the output to the user.
- ✓ All sorts of inputs and outputs are transmitted through the memory unit.

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2. Control Unit

As the name suggests, a control unit controls the operations of all parts of the computer but it does not carry out any data processing operations. For executing already stored instructions, It instructs the computer by using the electrical signals to instruct the computer system. It takes instructions from the memory unit and then decodes the instructions after that it executes those instructions. So, it controls the functioning of the computer. Its main task is to maintain the flow of information across the processor. Some main functions of the control unit are listed below:

- ✓ Controlling of data and transfer of data and instructions is done by the control unit among other parts of the computer.
- ✓ The control unit is responsible for managing all the units of the computer.
- ✓ The main task of the control unit is to obtain the instructions or data which is input from the memory unit, interprets them, and then directs the operation of the computer according to that.
- ✓ The control unit is responsible for communication with Input and output devices for the transfer of data or results from memory.
- ✓ The control unit is not responsible for the processing of data or storing data.

3. ALU (Arithmetic Logic Unit)

ALU (Arithmetic Logic Unit) is responsible for performing arithmetic and logical functions or operations. It consists of two subsections, which are:

- ***Arithmetic Section***
- ***Logic Section***

Now, let us know about these subsections:

Arithmetic Section: By arithmetic operations, we mean operations like addition, subtraction, multiplication, and division, and all these operation and functions are performed by ALU. Also, all the complex operations are done by making repetitive use of the mentioned operations by ALU.

Logic Section: By Logical operations, we mean operations or functions like selecting, comparing, matching, and merging the data, and all these are performed by ALU.

Note: CPU may contain more than one ALU and it can be used for maintaining timers that help run the computer system.

What Does a CPU Do?

The main function of a computer processor is to execute instruction and produce an output. CPU work are Fetch, Decode and Execute are the fundamental functions of the computer.

Fetch: the first CPU gets the instruction. That means binary numbers that are passed from RAM to CPU.

Decode: When the instruction is entered into the CPU, it needs to decode the instructions. with the help of ALU(Arithmetic Logic Unit) the process of decode begins.

Execute: After decode step the instructions are ready to execute

Strore: After execute step the instructions are ready to store in the memory.

Types of CPU

We have three different types of CPU:

- **Single Core CPU:** The oldest type of computer CPUs is single core CPU. These CPUs were used in the 1970s. these CPUs only have a single core that preform different operations. This means that the single core CPU can only process one operation at a single time. single core CPU CPU is not suitable for multitasking.
- **Dual-Core CPU:** Dual-Core CPUs contain a single Integrated Circuit with two cores. Each core has its cache and controller. These controllers and cache are work as a single unit. dual core CPUs can work faster than the single-core processors.
- **Quad-Core CPU:** Quad-Core CPUs contain two dual-core processors present within a single integrated circuit (IC) or chip. A quad-core processor contains a chip with four independent cores. These cores read

and execute various instructions provided by the CPU. Quad Core CPU increases the overall speed for programs. Without even boosting the overall clock speed it results in higher performance.

2.1.3 Memory

Memory is basically a device that has the capacity to store information. A memory unit is the amount of data that the memory can hold. Besides, we measure this storage capacity in terms of bytes. Moreover, there are different units of memory as per the requirement. Before studying the units of memory let us know about the memory.

Parts of Memory

1. **Primary Memory**

This is the internal memory that stores the data and instructions of the CPU. It is volatile in nature (data is lost when the power is disconnected).

The primary memory has two types:

1. **RAM (Random Access Memory)**

As per the name, data can be accessed randomly and quickly.

2. **ROM (Read Only Memory)**

As per the name, we can only read data and cannot write (store) to it.

2. **Secondary Memory**

As we know that the primary memory is volatile therefore, we need some devices to store the data permanently so we use some external storage devices for this

purpose which we name as the secondary memory. Some examples: CD, DVD, etc.

Types of Computer Memory

- **Cache memory.** This temporary storage area, known as a cache, is more readily available to the processor than the computer's main memory source. It is also called *CPU memory* because it is typically integrated directly into the CPU chip or placed on a separate chip with a bus interconnect with the CPU.

- **RAM.** It is one of the parts of the Main memory, also famously known as Read Write Memory. Random Access memory is present on the motherboard and the computer's data is temporarily stored in RAM. As the name says, RAM can help in both Read and write.

- **D RAM (Dynamic RAM):** D RAM uses capacitors and transistors and stores the data as a charge on the capacitors. They contain thousands of memory cells. It needs refreshing of charge on capacitor after a few milliseconds. This memory is slower than S RAM.

- **S RAM (Static RAM):** S RAM uses transistors and the circuits of this memory are capable of retaining their state as long as the power is applied. This memory consists of the number of flip flops with each flip flop storing 1 bit. It has less access time and hence, it is faster.

- **ROM:** ROM full form is Read Only Memory. ROM is a non volatile memory and it is used to store important information which is used to operate the system. We can only read the programs and data stored on it and cannot modify of delete it.

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- **MROM (Masked ROM):** Hard-wired devices with a pre-programmed collection of data or instructions were the first ROMs. Masked ROMs are a type of low-cost ROM that works in this way.

- **PROM (Programmable Read Only Memory):** This read-only memory is modifiable once by the user. The user purchases a blank PROM and uses a PROM program to put the required contents into the PROM. Its content can't be erased once written.

- **EPROM (Erasable Programmable Read Only Memory):** EPROM is an extension to PROM where you can erase the content of ROM by exposing it to Ultraviolet rays for nearly 40 minutes.

- **EEPROM (Electrically Erasable Programmable Read Only Memory):** Here the written contents can be erased electrically. You can delete and reprogramme EEPROM up to 10,000 times. Erasing and programming take very little time, i.e., nearly 4 -10 ms(milliseconds). Any area in an EEPROM can be wiped and programmed selectively.

- **Virtual memory.** A memory management technique where secondary memory can be used as if it were a part of the main memory. Virtual memory uses hardware and software to enable a computer to compensate for physical memory shortages by temporarily transferring data from RAM to disk storage.

Units of Memory

Memory units are used to measure the size and represent data. Some of the commonly used memory units are:

1. Bit

The first memory location in a computer is bit. The smallest measurement unit for data held in primary memory and storage devices is a bit. Out of the binary values 0 and 1, a bit can only have one.

- The smallest measurement unit for data in primary memory and storage devices.

- Represents binary values 0 and 1.

2. Nibble

- It means the group of 4 bits.

3. Word

It is a fixed number of bits, it is different from computer to computer, but the same for each device. Compute store information in the form of words.

- A fixed number of bits that varies across computers but remains consistent within each device.
- Used to store information in computers.

4. Bytes

The fundamental unit used to measure data is the byte. It has 8 bits in it. A byte can therefore represent 2 * 8 or 256 values. They determine the size of files, documents, photos, and other kinds of data.

- The fundamental unit for measuring data, consisting of 8 bits.
- Represents 256 values and determines file, document, photo, and data sizes.

5. Kilobyte

1024 bytes is equal to one kilobyte. It is widely used to denote small file sizes and data storage capacities. One kilobyte can hold a small image or around 1024 characters of text. It frequently shows up in text documents, spreadsheets, and small image files.

- Equal to 1024 bytes.
- Denotes small file sizes and storage capacities.
- Can hold small images or around 1024 characters of text.

6. Meghabyte

A megabyte is 1024 kilobytes in size. It contains more info as compared to a kilobyte. A megabyte can hold longer texts, high-resolution images, and short

audio clips. It is used to calculate the size of files comprising music and short films, software packages, and documents. Megabytes are still important and frequently used, even though larger units of measurement are being used more frequently as a result of the growing number of data files.

- Comprising 1024 kilobytes.
- Contains more information compared to a kilobyte.
- Holds longer texts, high-resolution images, and short audio clips.
- Measures file sizes of music, short films, software packages, and documents.

7. Gigabyte

1024 megabytes is equal to one gigabyte. It has a substantial amount of data storage space. Larger files, such full photo albums, high-definition movies, and software programs can fit within a gigabit. The storage capabilities of hard drives, solid-state drives, and other forms of data storage devices are routinely assessed utilizing this technique.

- Equal to 1024 megabytes.
- Offers substantial data storage space.
- Suitable for larger files, such as full photo albums, high-definition movies, and software programs.

8. Terabyte

A terabyte is made up of 1024 gigabytes. It has a substantial amount of data storing capacity. A terabyte can hold a lot of data in large databases, massive media collections, and enterprise-level storage systems. It is frequently used by data centers, cloud storage services, and external hard drives with large storage capacities. As the demand for large-scale data processing and storage grows, terabytes are becoming more and more important.

- Comprising 1024 gigabytes.

- Provides substantial data storing capacity.
- Holds large databases, media collections, and enterprise-level storage systems.

9. Petabyte

A petabyte is a colossal unit of data storage capacity. A petabyte may hold massive amounts of data, including significant video libraries, sizable databases, and sizable collections of high-resolution pictures. It is often used in data centers, cloud storage, and scientific research that uses a lot of data.

- A colossal unit of data storage capacity.
- Stores massive data quantities, like video libraries and large databases.

10. Exabyte (1024 petabytes)

An exabyte is equal to one EB. It has a substantial amount of data storage space. Exabytes can store vast film archives, massive data warehouses, and global internet traffic. It is extensively used in large-scale scientific simulations, cloud computing infrastructures, and enterprise-level storage systems.

- Equal to 1024 petabytes.
- Holds vast film archives, data warehouses, and global internet traffic.

11. Zettabyte (1024 exabytes)

A zettabyte. It represents a capacity for data storage that is almost unimaginable. Zettabytes have the capacity to store unfathomably large amounts of data, including worldwide internet content, long-term archival storage, and in-depth global data analysis.

- Represents an almost unimaginable data storage capacity.
- Stores worldwide internet content, long-term archival data, and extensive global analysis.

12. Yottabyte

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1024 zettabytes make up a yottabyte (abbreviated YB). It stands for an incredible amount of data storage. Unimaginable amounts of data, such as the equivalent of storing all of the material on the internet numerous times or tracking vast amounts, may be stored in yottabytes.

- Comprising 1024 zettabytes.
- Stands for an incredible amount of data storage.
- Can hold vast amounts equivalent to storing internet content numerous times.

Conversations of units

Name	Equal To	Size (In Bytes)
Bit	1 Bit	1/8
Nibble	4 Bits	1/2 (rare)
Byte	8 Bits	1
Kilobyte	1024 Bytes	1024
Megabyte	1024 Kilobytes	1, 048, 576
Gigabyte	1024 Megabytes	1, 073, 741, 824
Terabyte	1024 Gigabytes	1, 099, 511, 627, 776
Petabyte	1024 Terabytes	1, 125, 899, 906, 842, 624
Exabyte	1024 Petabytes	1, 152, 921, 504, 606, 846, 976
Zettabyte	1024 Exabytes	1, 180, 591, 620, 717, 411, 303, 424
Yottabyte	1024 Zettabytes	1, 208, 925, 819, 614, 629, 174, 706, 176

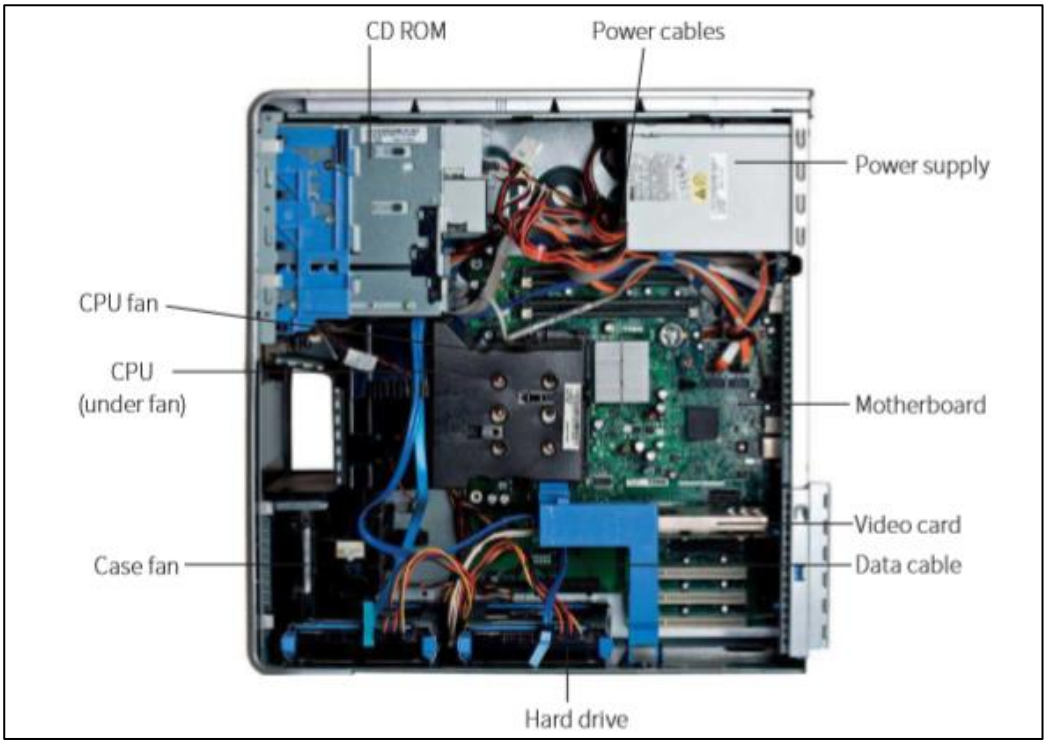
2.1.4 Other hardware components

Motherboard: a printed circuit board that allocates power to the CPU, RAM and other hardware components, and allows them to communicate with each other.

A video card, also known as a graphics card, can generate images, translate them and output them to a display.

A sound card lets you hear, record and play back sounds.

The power supply converts alternating current (AC) electricity from the mains supply to direct current (DC) electricity, and then supplies it to the other components.



A hard disk drive is for storing programs and data. The computer can read from and write to it. (When we say 'read from', it means being able to open a file from the hard disk and load its contents into memory; 'write to' means that we can save to the hard disk.) There are different types of disk drives but they generally work by spinning a disk and using a drive head to read/write. For hard drives a magnetic head is used.

The terms input and output say if data flow into or out of the computer. The picture shows the major hardware components of a computer system. The arrows show the direction of data flow.

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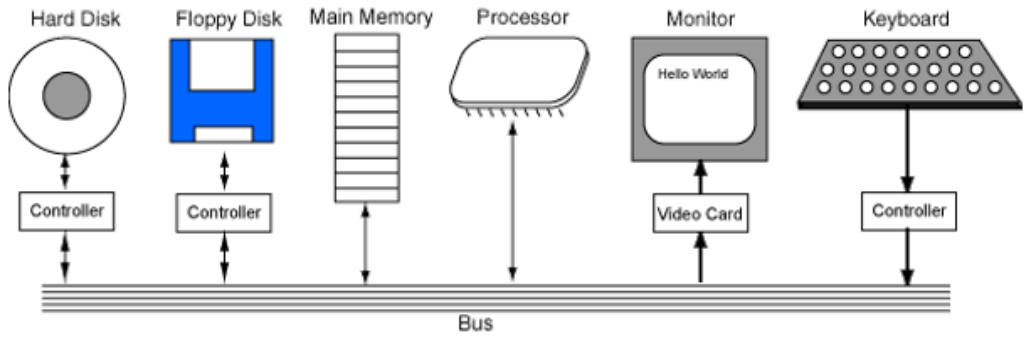


A bus is a group of wires on the main circuit board of the computer. It is a pathway for data flowing between components. Most devices are connected to the bus through a controller which coordinates the activities of the device with the bus.

2.2 COMPUTER SOFTWARE

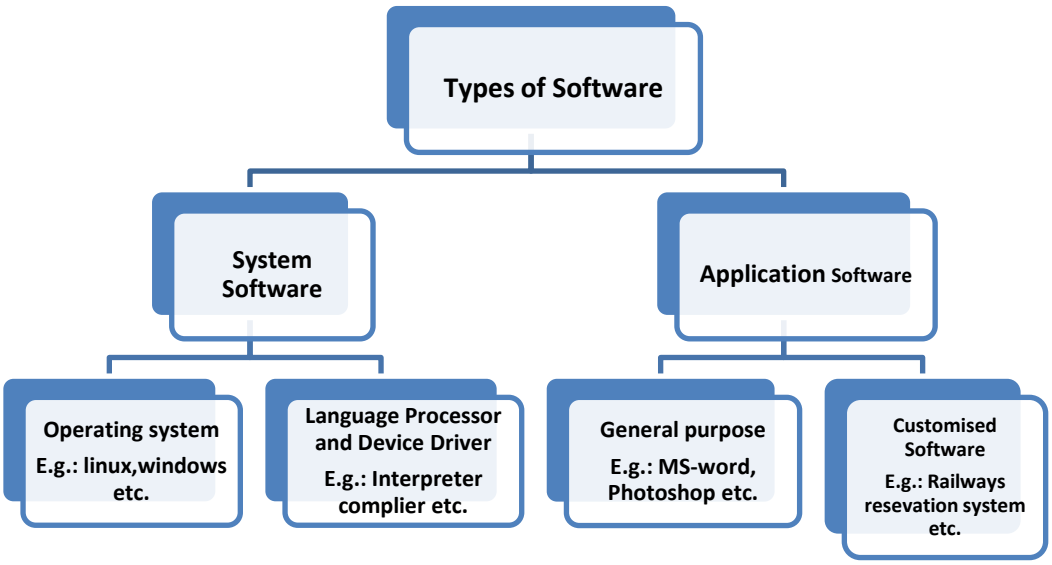
Software is a collection of instructions, data, or computer programs that are used to run machines and carry out particular activities. It is the antithesis of hardware, which refers to a computer's external components. A device's running programs, scripts, and applications are collectively referred to as "software" in this context.

2.2.1 What is a Software?

In a computer system, the software is basically a set of instructions or commands that tell a computer what to do. In other words, the software is a computer program that provides a set of instructions to execute a user's commands and tell the computer what to do. For example like MS-Word, MS-Excel, PowerPoint, etc.

2.2.2 Types of Software

It is a collection of data that is given to the computer to complete a particular task. The chart below describes the types of software:



Above is the diagram of types of software. Now we will briefly describe each type and its subtypes:

System Software

- Operating System
- Language Processor
- Device Driver

Application Software

- General Purpose Software
- Customize Software
- Utility Software
- System Software

System software is software that directly operates the computer hardware and provides the basic functionality to the users as well as to the other software to operate smoothly. Or in other words, system software basically controls a computer's internal functioning and also controls hardware devices such as monitors, printers, and storage devices, etc. It is like an interface between hardware and user applications, it helps them to communicate with each other because hardware understands machine language(i.e. 1 or 0) whereas user

applications are work in human-readable languages like English, Hindi, German, etc. so system software converts the human-readable language into machine language and vice versa.

Types of System Software

It has two subtypes which are:

Operating System: It is the main program of a computer system. When the computer system ON it is the first software that loads into the computer's memory. Basically, it manages all the resources such as computer memory, CPU, printer, hard disk, etc., and provides an interface to the user, which helps the user to interact with the computer system. It also provides various services to other computer software. Examples of operating systems are Linux, Apple macOS, Microsoft Windows, etc.

Language Processor: As we know that system software converts the human-readable language into a machine language and vice versa. So, the conversion is done by the language processor. It converts programs written in high-level programming languages like Java, C, C++, Python, etc(known as source code), into sets of instructions that are easily readable by machines(known as object code or machine code).

Device Driver: A device driver is a program or software that controls a device and helps that device to perform its functions. Every device like a printer, mouse, modem, etc. needs a driver to connect with the computer system eternally. So, when you connect a new device with your computer system, first you need to install the driver of that device so that your operating system knows how to control or manage that device.

Features of System Software

Let us discuss some of the features of System Software:

- ✓ System Software is closer to the computer system.
- ✓ System Software is written in a low-level language in general.
- ✓ System software is difficult to design and understand.

- ✓ System software is fast in speed (working speed).
- ✓ System software is less interactive for the users in comparison to application software.

Application Software Software that performs special functions or provides functions that are much more than the basic operation of the computer is known as application software. Or in other words, application software is designed to perform a specific task for end-users. It is a product or a program that is designed only to fulfill end-users' requirements. It includes word rocessors, spreadsheets, database management, inventory, payroll programs, etc.

Types of Application Software

There are different types of application software and those are:

General Purpose Software: This type of application software is used for a variety of tasks and it is not limited to performing a specific task only. For example, MS-Word, MS-Excel, PowerPoint, etc.

Customized Software: This type of application software is used or designed to perform specific tasks or functions or designed for specific organizations. For example, railway reservation system, airline reservation system, invoice management system, etc.

Utility Software: This type of application software is used to support the computer infrastructure. It is designed to analyze, configure, optimize and maintains the system, and take care of its requirements as well. For example, antivirus, disk fragmenter, memory tester, disk repair, disk cleaners, registry cleaners, disk space analyzer, etc.

Features of Application Software

Let us discuss some of the features of Application Software:

- ✓ An important feature of application software is it performs more specialized tasks like word processing, spreadsheets, email, etc.
- ✓ Mostly, the size of the software is big, so it requires more storage space.

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- ✓ Application software is more interactive for the users, so it is easy to use and design.
- ✓ The application software is easy to design and understand.
- ✓ Application software is written in a high-level language in general.

Difference Between System Software and Application Software

Now, let us discuss some difference between system software and application software:

System Software	Application Software
It is designed to manage the resources of the computer system, like memory and process management, etc.	It is designed to fulfill the requirements of the user for performing specific tasks.
Written in a low-level language.	Written in a high-level language.
Less interactive for the users.	More interactive for the users.
System software plays vital role for the effective functioning of a system.	Application software is not so important for the functioning of the system, as it is task specific.
It is independent of the application software to run.	It needs system software to run.

QUESTIONS

1. What is a CPU?
2. What are types of CPU?
3. What are CPUs made of?
4. What are different parts of CPU?
5. Describe some characteristics of input devices.

6. Why does a computer need an input device?
7. Is a scanner an input or output device?
8. What is the importance of an output device?
9. Name some devices which works as both Output and Input Device?
10. Which device gives us hard copy as output?
11. What is difference between hard copy and soft copy?
12. List the Disadvantages of CRT Monitor?
13. What are the types of flat-panel displays?
14. Explain the output device: Plotter?
15. What is memory unit in CPU?
16. How does memory unit work?
17. Which is the smallest unit of measurement of data?
18. What is difference between a software and a program?
19. What is an example of Software?
20. Which software is used to control the operations of a computer?
21. Which software is designed to solve a specific problem or to do a specific task?
22. Compare Input & Output Devices.

Input Device	Output Device
Data is accepted by the user of the device	It shows the data after processing to the user
It accepts the user's data and transmits it to the processor for saving in the secondary memory or processing.	It receives the data from the processor and returns it to the user
More complex designing	Less complex designing
These devices are used to accept the data	These devices are used to display or show the data
Example: Keyboard, mouse, etc	Example: Monitor, Printer, etc

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23. Compare Impact & Non-Impact Printers.

Impact Printers	Non-Impact Printers
Slow Speed	Fast Speed
Makes a lot of Noisy	They are less Noisy
Cheap	Costly
Poor quality as compared to non-impact printers	Good quality printing
It works by hammering a set of metal pins or a character set into the paper	Ink is deposited in several forms during printing

24. What is the difference between memory and storage?

Memory	Storage
Primary memory	Secondary memory
Short-term data processing	Long-term data storage
RAM (Random Access Memory)	Hard Drive, SSD, HDD
Volatile (Data is lost when computer is off)	Nonvolatile (Data is retained after power-off)
Location of data processing	Location where data is kept
Smaller space compared to storage	Larger space compared to memory
Less space (e.g., 8 GB) for running programs	More space (e.g., 250 GB) for storing data
Refer to volatility or nonvolatility	Refer to primary or secondary nature

3. DATA REPRESENTATION

We use computer to process the data and get the desired output. The data input can be in the form of alphabets, digits, symbols, audio, video, magnetic cards, finger prints, etc. Since computer can only understand 0 and 1, the data must be represented in the computer in 0s and 1s. The purpose of this chapter is to introduce you to the data representation in the computer.

3.1 INTRODUCTION

The data stored in the computer may be of different kinds, as follows:

- Numeric data (0, 1, 2, …, 9)
- Alphabetic data (A, B, C, …, Z)
- Alphanumeric data—Combination of any of the symbols—(A, B, C… Z), (0, 1… 9), or special characters (+,–, Blank), etc.

All kinds of data, be it alphabets, numbers, symbols, sound data or video data, is represented in terms of 0s and 1s, in the computer. Each symbol is represented as a unique combination of 0s and 1s.

This chapter discusses the number systems that are commonly used in the computer. The number systems discussed in this chapter are—(1) Decimal number system, (2) Binary number system, (3) Octal number system, and (4) Hexadecimal number system. The number conversions described in this chapter are:

- Decimal (Integer, Fraction, Integer.Fraction) to Binary, Octal, Hexadecimal
- Binary, Octal, Hexadecimal (Integer, Fraction, Integer.Fraction) to Decimal
- Binary to Octal, Hexadecimal
- Octal, Hexadecimal to Binary

The chapter also discusses the binary arithmetic operations and the representation of signed and unsigned numbers in the computer. The

representation of numbers using binary coding schemes and the logic gates used for the manipulation of data are also discussed.

3.2 NUMBER SYSTEM

A number system in *base r or radix r* uses unique symbols for r digits. One or more digits are combined to get a number. The base of the number decides the valid digits that are used to make a number. In a number, the *position* of digit starts from the right-hand side of the number. The rightmost digit has position 0, the next digit on its left has position 1, and so on. The digits of a number have two kinds of values:

- Face value, and
- Position value.

The **face value** of a digit is the digit located at that position. For example, in decimal number 52, face value at position 0 is 2 and face value at position 1 is 5.

The **position value** of a digit is (base position). For example, in decimal number 52, the position value of digit 2 is 100 and the position value of digit 5 is 101. Decimal numbers have a base of 10.

The **number** is calculated as the sum of, face value * base position, of each of the digits. For decimal number 52, the number is 5*101 + 2*100 = 50 + 2 = 52

In computers, we are concerned with four kinds of number systems, as follows:

- Decimal Number System —Base 10
- Binary Number System —Base 2
- Octal Number System —Base 8
- Hexadecimal Number System—Base 16

The numbers given as input to computer and the numbers given as output from the computer, are generally in decimal number system, and are most easily understood by humans. However, computer understands the binary number system, i.e., numbers in terms of 0s and 1s. The binary data is also represented, internally, as octal numbers and hexadecimal numbers due to their ease of use.

A number in a particular base is written as (number)base of number For example, (23)10 means that the number 23 is a decimal number, and (345)8 shows that 345 is an octal number.

3.2.1 Decimal Number System

It consists of 10 digits—0, 1, 2, 3, 4, 5, 6, 7, 8 and 9.

All numbers in this number system are represented as combination of digits 0—9. For example, 34, 5965 and 867321.

3.2.2 Binary Number System

The binary number system consists of two digits—0 and 1.

All binary numbers are formed using combination of 0 and 1. For example, 1001, 11000011 and 10110101.

The position value and quantity of a digit at different positions in a number are as follows:

Position:	3	2	1	0	.	–1	–2	–3
Position Value:	2^3	2^2	2^1	2^0		2^{-1}	2^{-2}	2^{-3}
Quantity:	8	4	2	1		1/2	1/4	1/8

3.2.3 Octal Number System

The octal number system consists of eight digits—0 to 7.

All octal numbers are represented using these eight digits. For example, 273, 103, 2375, etc.

The position value and quantity of a digit at different positions in a number are as follows:

Position:	3	2	1	0	.	–1	–2	–3
Position Value:	8^3	8^2	8^1	8^0		8^{-1}	8^{-2}	8^{-3}
Quantity:	512	64	8	1		1/8	1/64	1/512

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3.2.4 Hexadecimal Number System

The hexadecimal number system consists of sixteen digits—0 to 9, A, B, C, D, E, F, where (A is for 10, B is for 11, C-12, D-13, E-14, F-15).

All hexadecimal numbers are represented using these 16 digits. For example, 3FA, 87B, 113, etc.

The position value and quantity of a digit at different positions in a number are as follows:

Position:	3	2	1	0	.	−1	−2	−3
Position Value:	16^3	16^2	16^1	16^0		16^{-1}	16^{-2}	16^{-3}
Quantity:	4096	256	16	1		1/16	1/256	1/4096

The following table summarizes the base, digits and largest digit for the above discussed number systems.

	Base	Digits	Largest Digit
Decimal	10	0–9	9
Binary	2	0,1	1
Octal	8	0–7	7
Hexadecimal	16	0–9, A, B, C, D, E, F	F (15)

The following table shows the binary, octal and hexadecimal equivalents of the decimal numbers 0–16.

Decimal	Binary	Octal	Hexadecimal
0	0000	000	0
1	0001	001	1
2	0010	002	2
3	0011	003	3
4	0100	004	4
5	0101	005	5
6	0110	006	6
7	0111	007	7
8	1000	010	8
9	1001	011	9
10	1010	012	A
11	1011	013	B
12	1100	014	C
13	1101	015	D
14	1110	016	E
15	1111	017	F
16	10000	020	10

3.3 CONVERSION FROM DECIMAL TO BINARY, OCTAL, HEXADECIMAL

A decimal number has two parts—integer part and fraction part. For example, in the decimal number 23.0786, 23 is the integer part and .0786 is the fraction part. The method used for the conversion of the integer part of a decimal number is different from the one used for the fraction part. In the following subsections, we shall discuss the conversion of decimal integer, decimal fraction and decimal integer.fraction number into binary, octal and hexadecimal number.

3.3.1 Converting Decimal *Integer* to Binary, Octal, Hexadecimal

A decimal integer is converted to any other base, by using the division operation.

To convert a decimal integer to:

- ✓ binary-divide by 2,
- ✓ octal-divide by 8, and,
- ✓ hexadecimal-divide by 16.

==========

Let us now understand this conversion with the help of some examples.

Example: Convert 25 from Base 10 to Base 2.

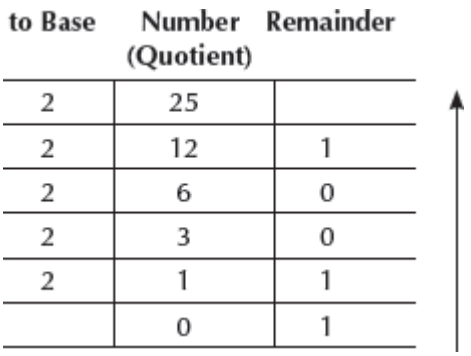
Make a table as shown below. Write the number in centre and to Base on the left side.

to Base	Number (Quotient)	Remainder
2	25	

Divide the number with *to Base*. After each division, write the remainder on right-side column and quotient in the next line in the middle column. Continue dividing till the quotient is 0.

to Base	Number (Quotient)	Remainder
2	25	
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

Write the digits in *remainder column* starting from *downwards to upwards*,



to Base	Number (Quotient)	Remainder
2	25	
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

The binary equivalent of number $(25)_{10}$ is $(11001)_2$

The steps shown above are followed to convert a decimal integer to a number in any other base.

Example: Convert 23 from Base 10 to Base 2, 8, 16.

to Base	Number (Quotient)	Remainder
2	23	
2	11	1
2	5	1
2	2	1
2	1	0
	0	1

The binary equivalent of $(23)_{10}$ is $(10111)_2$

to Base	Number (Quotient)	Remainder
8	23	
8	2	7
	0	2

The octal equivalent of $(23)_{10}$ is $(27)_8$

to Base	Number (Quotient)	Remainder
16	23	
16	1	7
	0	1

The hexadecimal equivalent of $(23)_{10}$ is $(17)_{16}$

Example : Convert 147 from Base 10 to Base 2, 8 and 16.

to Base	Number (Quotient)	Remainder
2	147	
2	73	1
2	36	1
2	18	0
2	9	0
2	4	1
2	2	0
2	1	0
	0	1

The binary equivalent of $(147)_{10}$ is $(10010011)_2$

to Base	Number (Quotient)	Remainder
8	147	
8	18	3
8	2	2
	0	2

The octal equivalent of $(147)_{10}$ is $(223)_8$

to Base	Number (Quotient)	Remainder
16	147	
16	9	3
	0	9

The hexadecimal equivalent of $(147)_{10}$ is $(93)_{16}$

3.3.2 Converting Decimal Fraction to Binary, Octal, Hexadecimal

A fractional number is a number less than 1. It may be .5, .00453, .564, etc. We use the multiplication operation to convert decimal fraction to any other base.

To convert a decimal fraction to:

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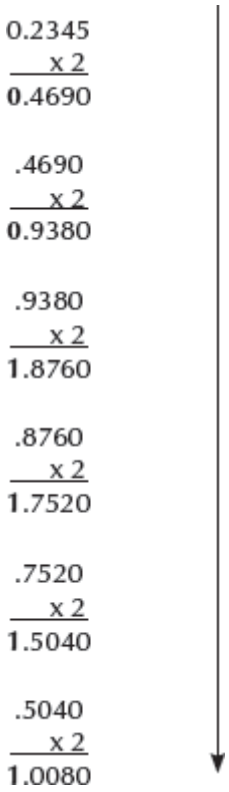
- ✓ binary-multiply by 2,
- ✓ octal-multiply by 8, and,
- ✓ hexadecimal-multiply by 16.

Steps for conversion of a decimal fraction to any other base are:

- Multiply the fractional number with the to *Base*, to get a resulting number.
- The resulting number has two parts, non-fractional part and fractional part.
- Record the non-fractional part of the resulting number.
- Repeat the above steps at least four times.
- Write the digits in the non-fractional part starting from upwards to downwards.

Example: Convert 0.2345 from Base 10 to Base 2.



The binary equivalent of (0.2345)10 is (0.001111)2

Example: Convert 0.865 from Base 10 to Base 2,8 and 16.

0.865 x 2 1.730 x 2 1.460 x 2 0.920 x 2 1.840 x 2 1.680 x 2 1.360	0.865 x 8 6.920 x 8 7.360 x 8 2.880 x 8 7.040	0.865 x 16 5190 865 x 13.840 x 16 5040 840 x 13.440 x 16 2640 440 x 7.040
The binary equivalent of $(.865)_{10}$ is $(.110111)_2$	The octal equivalent of $(0.865)_{10}$ is $(.6727)_8$	The number 13 in hexadecimal is D. The hexadecimal equivalent of $(0.865)_{10}$ is $(.DD7)_{16}$

3.3.3 Converting Decimal Integer.Fraction to Binary, Octal, Hexadecimal

A decimal *integer.fraction* number has both integer part and fraction part. The steps for conversion of a decimal *integer.fraction* to any other base are:

Convert decimal integer part to the desired base following the steps shown in section 3.3.1.

Convert decimal fraction part to the desired base following the steps shown in section 3.3.2.

The integer and fraction part in the desired base is combined to get integer.fraction.

Example: Convert 34.4674 from Base 10 to Base 2.

to Base	Number (Quotient)	Remainder
2	34	
2	17	0
2	8	1
2	4	0
2	2	0
2	1	0
	0	1

The binary equivalent of $(34)_{10}$ is $(100010)_2$

0.4674
x 2
0.9348
x 2
1.8696
x 2
1.7392
x 2
1.4784
x 2
0.9568
x 2
1.8136

The binary equivalent of $(0.4674)_{10}$ is $(.011101)_2$

The binary equivalent of $(34.4674)_{10}$ is $(100010.011101)_2$

==========

Example: Convert 34.4674 from Base 10 to Base 8.

to Base	Number (Quotient)	Remainder
8	34	
8	4	2
	0	4

The octal equivalent of $(34)_{10}$ is $(42)_8$

0.4674
x 8
3.7392
x 8
5.9136
x 8
7.3088
x 8
2.4704

The octal equivalent of $(0.4674)_{10}$ is $(.3572)_8$

The octal equivalent of $(34.4674)_{10}$ is $(42.3572)_8$

Example: Convert 34.4674 from Base 10 to Base 16.

to Base	Number (Quotient)	Remainder
16	34	
16	4	2
	0	2

The hexadecimal equivalent of $(34)_{10}$ is $(22)_{16}$

0.4674
x 16
28044
4674x
9.4784
x 16
28704
4784x
7.6544
x 16
39264
6544x
10.4904
x 16
29424
4904x
7.8464

The hexadecimal equivalent of $(0.4674)_{10}$ is $(.97A7)_{16}$

The hexadecimal equivalent of $(34.4674)_{10}$ is $(22.97A7)_{16}$

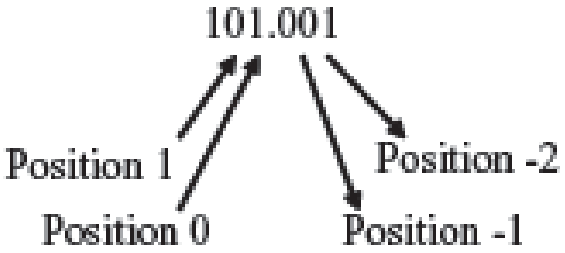
3.4 CONVERSION OF BINARY, OCTAL, HEXADECIMAL TO DECIMAL

A binary, octal or hexadecimal number has two parts—integer part and fraction part. For example, a binary number could be 10011, 0.011001 or 10011.0111. The

numbers 45, .362 or 245.362 are octal numbers. A hexadecimal number could be A2, .4C2 or A1.34.

The method used for the conversion of integer part and fraction part of binary, octal or hexadecimal number to decimal number is the same; multiplication operation is used for the conversion. The conversion mechanism uses the face value and position value of digits. The steps for conversion are as follows:

- Find the sum of the *Face Value * (fromBase)position* for each digit in the number.
- *In a non-fractional number, the rightmost digit has position 0 and the position increases as we go towards the left.*
- *In a fractional number, the first digit to the left of decimal point has position 0 and the position increases as we go towards the left. The first digit to the right of the decimal point has position –1 and it decreases as we go towards the right (–2, –3, etc.)*



Example: Convert 1011 from Base 2 to Base 10.

Convert 62 from Base 8 to Base 10.

Convert C15 from Base 16 to Base 10.

1011 fromBase 2 toBase 10	62 fromBase 8 toBase 10	C15 fromBase 16 toBase 10
$1011 = 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0$	$62 = 6*8^1 + 2*8^0$	$C15 = C*16^2 + 1*16^1 + 5*16^0$
$= 1*8 + 0*4 + 1*2 + 1*1$	$= 6*8 + 2*1$	$= 12*256 + 1*16 + 5*1$
$= 8 + 0 + 2 + 1$	$= 48 + 2$	$= 3072 + 16 + 5$
$= 11$	$= 50$	$= 3093$
The decimal equivalent of $(1011)_2$ is 11.	The decimal equivalent of $(62)_8$ is 50.	The decimal equivalent of $(C15)_{16}$ is 3093

Example: Convert .1101 from Base 2 to Base 10.

==========

Convert .345 from Base 8 to Base 10.

Convert .15 from Base 16 to Base 10.

.1101 fromBase 2 toBase 10	.345 fromBase 8 toBase 10	.15 fromBase 16 toBase 10
$.1101 = 1*2^{-1} + 1*2^{-2} + 0*2^{-3} + 1*2^{-4}$	$.345 = 3*8^{-1} + 4*8^{-2} + 5*8^{-3}$	$.15 = 1*16^{-1} + 5*16^{-2}$
$= 1/2 + 1/4 + 0 + 1/16$	$= 3/8 + 4/64 + 5/512$	$= 1/16 + 5/256$
$= 13/16$	$= 229/512$	$= 21/256$
$= .8125$	$= .447$	$= .082$
The decimal equivalent of $(.1101)_2$ is .8125	The decimal equivalent of $(.345)_8$ is .447	The decimal equivalent of $(.15)_{16}$ is .082

Example: Convert 1011.1001 from Base 2 to Base 10.

Convert 24.36 from Base 8 to Base 10.

Convert 4D.21 from Base 16 to Base 10.

1011.1001 fromBase 2 toBase 10	24.36 fromBase 8 toBase 10	4D.21 fromBase 16 toBase 10
		$4D.21 = 4*16^1 + D*16^0 + 2*16^{-1} + 1*16^{-2}$
$1011.1001 = 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0 + 1*2^{-1} + 0*2^{-2} + 0*2^{-3} + 1*2^{-4}$	$24.36 = 2*8^1 + 4*8^0 + 3*8^{-1} + 6*8^{-2}$	
		$= 64 + 13 + 2/16 + 1/256$
$= 8 + 0 + 2 + 1 + 1/2 + 0 + 0 + 1/16$	$= 16 + 4 + 3/8 + 6/64$	$= 77 + 33/256$
$= 11 + 9/16$	$= 20 + 30/64$	
		$= 77.1289$
$= 11.5625$	$= 20.4687$	
The decimal equivalent of $(1011.1001)_2$ is 11.5625	The decimal equivalent of $(24.36)_8$ is 20.4687	The decimal equivalent of $(4D.21)_{16}$ is 77.1289

3.5 BINARY ARITHMETIC

The arithmetic operations—addition, subtraction, multiplication and division, performed on the binary numbers is called *binary arithmetic*. In computer, the basic arithmetic operations performed on the binary numbers is:

- Binary addition, and
- Binary subtraction.

In the following subsections, we discuss the binary addition and the binary subtraction operations.

3.5.1 Binary Addition

Binary addition involves addition of two or more binary numbers. The *binary addition* rules are used while performing the binary addition. the following table shows the binary addition rules.

Input 1	Input 2		Sum	Carry
0	0	→	0	No carry
0	1	→	1	No carry
1	0	→	1	No carry
1	1	→	0	1

Binary addition of three inputs follows the rule shown as.

Input 1	Input 2	Input 3		Sum	Carry
0	0	0	→	0	No Carry
0	0	1	→	1	No Carry
0	1	0	→	1	No Carry
0	1	1	→	0	1
1	0	0	→	1	No Carry
1	0	1	→	0	1
1	1	0	→	0	1
1	1	1	→	1	1

==========

Addition of the binary numbers involves the following steps:

- ✓ Start addition by adding the bits in unit column (the right-most column). Use the rules of binary addition.
- ✓ The result of adding bits of a column is a sum with or without a carry.
- ✓ Write the sum in the result of that column.
- ✓ If a carry is present, the carry is carried-over to the addition of the next left column.
- ✓ Repeat steps 2–4 for each column, i.e., the tens column, hundreds column and so on.

Let us now understand binary addition with the help of some examples.

Example: Add 10 and 01. Verify the answer with the help of decimal addition.

Binary Addition	Decimal Addition
1 0 + 0 1 Result 1 1	2 + 1 3
$11_2 = 3_{10}$	

Example: Add 01 and 11. Verify the answer with the help of decimal addition.

Binary Addition	Decimal Addition
1 1 ← Carry 0 1 + 1 1 Result 1 0 0	1 + 3 4
$100_2 = 4_{10}$	

Example: Add 11 and 11. Verify the answer with the help of decimal addition.

Binary Addition	Decimal Addition
1 1 ← Carry 1 1 + 1 1 Result 1 1 0	3 + 3 6
$110_2 = 6_{10}$	

Example: Add 1101 and 1111. Verify the answer with the help of decimal addition.

Binary Addition	Decimal Addition
1 1 1 1 ← Carry 1 0 0 1 + 1 1 1 1 1 1 0 0 0	9 + 1 5 2 4
$11000_2 = 24_{10}$	

Example: Add 10111, 11100 and 11. Verify the answer with the help of decimal addition.

Binary Addition	Decimal Addition
1 1 1 1 1 ← Carry 1 0 1 1 1 + 1 1 0 0 0 1 1 1 1 1 0 1 1 0	2 3 + 2 4 7 5 4
$110110_2 = 54_{10}$	

3.5.2 Binary Subtraction

Binary subtraction involves subtracting of two binary numbers. The *binary subtraction rules* are used while performing the binary subtraction. The binary subtraction rules are shown in the following table, where "Input 2" is subtracted from "Input 1."

Input 1	Input 2		Difference	Borrow
0	0	→	0	No borrow
0	1	→	1	1
1	0	→	1	No borrow
1	1	→	0	No borrow

The steps for performing subtraction of the binary numbers are as follows—

- ✓ Start subtraction by subtracting the bit in the lower row from the upper row, in the unit column.

- ✓ Use the binary subtraction rules. If the bit in the upper row is less than lower row, *borrow* 1 from the upper row of the next column (on the left side). The result of subtracting two bits is the *difference*.
- ✓ Write the *difference* in the result of that column.
- ✓ Repeat steps 2 and 3 for each column, i.e., the tens column, hundreds column and so on.

Let us now understand binary subtraction with the help of some examples.

Example: Subtract 01 from 11. Verify the answer with the help of decimal subtraction.

Binary Subtraction	Decimal Subtraction
1 1 − 0 1 Result 1 0	3 − 1 2
$10_2 = 2_{10}$	

Example: Subtract 01 from 10. Verify the answer with the help of decimal subtraction.

Binary Subtraction	Decimal Subtraction
0 10 + 0 − 0 1 0 1	2 − 1 1
$01_2 = 1_{10}$	

Example: Subtract 0111 from 1110. Verify the answer with the help of decimal subtraction.

Binary Subtraction	Decimal Subtraction
0 10 0 10 0 10 } Borrow + + + 0 − 0 1 1 1 0 1 1 1	1 4 − 0 7 7
$0111_2 = 7_{10}$	

Example: Subtract 100110 from 110001. Verify the answer with the help of decimal subtraction.

Binary Subtraction	Decimal Subtraction
1 1 ~~1~~0 ~~1~~0 10 Borrow 1 1 0 0 0 1 1 0 0 1 1 0 0 0 1 0 1 1	4 9 − 3 8 1 1
$001011_2 = 11_{10}$	

3.6 SIGNED AND UNSIGNED NUMBERS

A binary number may be positive or negative. Generally, we use the symbol "+" and "–" to represent positive and negative numbers, respectively. The sign of a binary number has to be represented using 0 and 1, in the computer. An *n-bit signed binary number* consists of two parts—sign bit and magnitude. The left most bit, also called the Most Significant Bit (MSB) is the sign bit. The remaining n-1 bits denote the *magnitude* of the number.

In signed binary numbers, the sign bit is 0 for a positive number and 1 for a negative number. For example, 01100011 is a positive number since its sign bit is 0, and, 11001011 is a negative number since its sign bit is 1. An 8–bit signed number can represent data in the range –128 to +127 (–27to +27–1). The left-most bit is the sign bit.

In an *n-bit unsigned binary number*, the magnitude of the number n is stored in n bits. An 8–bit unsigned number can represent data in the range 0 to 255 (28 = 256).

3.6.1 Complement of Binary Numbers

Complements are used in computer for the simplification of the subtraction operation. For any number in base r, there exist two complements: (1) *r's* complement and (2) *r*-1 *'s* complement.

Number System	Base	Complements possible
Binary	2	1's complement and 2's complement
Octal	8	7's complement and 8's complement
Decimal	10	9's complement and 10's complement
Hexadecimal	16	15's complement and 16's complement

Let us now see how to find the complement of a binary number. There are two types of complements for the binary number system—1's complement and 2's complement.

- ***1's Complement of Binary Number*** is computed by changing the bits 1 to 0 and the bits 0 to 1. For example,

  1's complement of 101 is 010

  1's complement of 1011 is 0100

  1's complement of 1101100 is 0010011

- **2's Complement of Binary Number** is computed by adding 1 to the 1's complement of the binary number. For example,

  2's complement of 101 is 010 + 1 = 011

  2's complement of 1011 is 0100 + 1 = 0101

  2's complement of 1101100 is 0010011 + 1 = 0010100

The rule to find the complement of any number N in base r having n digits is

(r − 1)'s complement—$(r^n - 1) - N$

(r's) complement2—$(r^n - 1) - N + 1 = (r^n - N)$

3.7 BINARY DATA REPRESENTATION

A binary number may also have a binary point, in addition to the sign. The binary point is used for representing fractions, integers and integer-fraction numbers. *Registers* are high-speed storage areas within the Central Processing Unit (CPU) of the computer. All data are brought into a register before it can be

processed. For example, if two numbers are to be added, both the numbers are brought in registers, added, and the result is also placed in a register. There are two ways of representing the position of the binary point in the register—fixed point number representation and floating point number representation.

The *fixed point number representation assumes* that the binary point is fixed at one position either at the extreme left to make the number a fraction, or at the extreme right to make the number an integer. In both cases, the binary point is not stored in the register, but the number is treated as a fraction or integer. For example, if the binary point is assumed to be at extreme left, the number 1100 is actually treated as 0.1100.

The *floatingpoint number representation* uses two registers. The first register stores the number without the binary point. The second register stores a number that indicates the position of the binary point in the first register.

We shall now discuss representation of data in the fixed point number representation and floating point number representation.

3.7.1 Fixed Point Number Representation

The integer binary signed number is represented as follows:

- For a positive integer binary number, the sign bit is 0 and the magnitude is a positive binary number.
- For a negative integer binary number, the sign bit is 1. The magnitude is represented in any one of the three ways:
    - ***Signed Magnitude Representation***—The magnitude is the positive binary number itself.
    - ***Signed 1 's Complement Representation***—The magnitude is the 1's complement of the positive binary number.
    - ***Signed 2's Complement Representation***—The magnitude is the 2's complement of the positive binary number.

The following table shows the representation of the signed number 18.

+18	0 0010010		Sign bit is 0. 0010010 is binary equivalent of +18
−18	Signed magnitude representation	1 0010010	Sign bit is 1. 0010010 is binary equivalent of +18
	Signed 1's complement representation	1 1101101	Sign bit is 1. 1101101 is 1's complement of +18
	Signed 2's complement representation	1 1101110	Sign bit is 1. 1101110 is 2's complement of +18

Signed magnitude and signed 1's complement representation are seldom used in computer arithmetic.

Let us now perform arithmetic operations on the signed binary numbers. We use the signed 's complement representation to represent the negative numbers.

- ***Addition of Signed Binary Numbers***—The addition of any two signed binary numbers is performed as follows:
  - Represent the positive number in binary form.(For example, +5 is 0000 0101 and +10 is 0000 1010)
  - Represent the negative number in 's complement form. (For example, —5 is 1111 1011 and −10 is 1111 0110)
  - Add the bits of the two signed binary numbers.
  - Ignore any carry out from the sign bit position.

Please note that the negative output is automatically in the 's complement form.

We get the decimal equivalent of the negative output number, by finding its 2's complement, and attaching a negative sign to the obtained result.

Let us understand the addition of two signed binary numbers with the help of some examples.

Example: Add +5 and +10.

+5 in binary form, i.e., 0000 0101. +10 in binary form, i.e., 0000 1010.

Binary Addition	Decimal Addition
0 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 0 0 1 1 1 1	+ 5 + 1 0 + 1 5
The result is 0000 1111_2 i.e, $+15_{10}$	

Example: Add −5 and +10.

−5 in ’s complement form is 1111 1011. +10 in binary form is 0000 1010.

Binary Addition	Decimal Addition
1 1 1 1 1 0 1 1	− 5
0 0 0 0 1 0 1 0	+1 0
0 0 0 0 0 1 0 1	+ 5
The result is 0000 0101_2, i.e., $+5_{10}$	

Example: Add +5 and −10.

+5 in binary form is 0000 0101. −10 in ’s complement form is 1111 0110. 1111 1011.

Binary Addition	Decimal Addition
0 0 0 0 0 1 0 1	+ 5
1 1 1 1 0 1 1 0	− 1 0
1 1 1 1 1 0 1 1	− 5
The result is 1111 1011_2, i.e., -5_{10}	

The result is in 2’s complement form. To find its decimal equivalent—

Find the 2’s complement of 1111 1011, i.e., 0000 0100 + 1 = 0000 0101. This is binary equivalent of + 5. Attaching a negative sign to the obtained result gives us −5.

Example: Add −5 and −10.

−5 in ’s complement form is 1111 1011. −10 in 2’s complement form is 1111 0110.

Binary Addition	Decimal Addition
1 1 1 1 1 0 1 1	− 5
1 1 1 1 0 1 1 0	− 1 0
1 1 1 1 0 0 0 1	− 1 5
The result is 1111 0001_2, i.e., -15_{10}	

The result is in 2’s complement form. To find its decimal equivalent—

Find the ’s complement of 1111 0001, i.e., 0000 1110 + 1 = 0000 1111. This is binary equivalent of +15. Attaching a negative sign to the obtained result gives us −15.

- ***Subtraction of Signed Binary Numbers—***The subtraction of signed binary numbers is changed to the addition of two signed numbers. For this, the sign of the second number is changed before performing the addition operation.

(−A) − (+B) = (−A) + (−B)	(+B in subtraction is changed to −B in addition)
(+A) − (+B) = (+A) + (−B)	(+B in subtraction is changed to −B in addition)
(−A) − (−B) = (−A) + (+B)	(−B in subtraction is changed to +B in addition)
(+A) − (−B) = (+A) + (+B)	(−B in subtraction is changed to +B in addition)

We see that the subtraction of signed binary numbers is performed using the addition operation.

The hardware logic for the fixed point number representation is simple, when we use ’s complement for addition and subtraction of the signed binary numbers. When two large numbers having the same sign are added, then an overflow may occur, which has to be handled.

3.7.2 Floating Point Number Representation

The floating point representation of a number has two parts—mantissa and exponent. The mantissa is a signed fixed point number. The exponent shows the position of the binary point in the mantissa.

For example, the binary number +11001.11 with an 8–bit mantissa and 6–bit exponent is represented as follows:

- Mantissa is 01100111. The left most 0 indicates that the number is positive.
- Exponent is 000101. This is the binary equivalent of decimal number + 5.
- The floating point number is Mantissa x 2exponent, i.e., + (.1100111) x 2+5.

The arithmetic operation with the floating point numbers is complicated, and uses complex hardware as compared to the fixed point representation. However, floating point calculations are required in scientific calculations, so, computers have a built–in hardware for performing floating point arithmetic operations.

3.8 BINARY CODING SCHEMES

The alphabetic data, numeric data, alphanumeric data, symbols, sound data and video data, are represented as combination of bits in the computer. The bits are grouped in a fixed size, such as 8 bits, 6 bits or 4 bits. A code is made by combining bits of definite size. *Binary Coding schemes* represent the data such as alphabets, digits 0–9, and symbols in a standard code. A combination of bits represents a unique symbol in the data. The standard code enables any programmer to use the same combination of bits to represent a symbol in the data.

The binary coding schemes that are most commonly used are:

- Extended Binary Coded Decimal Interchange Code (EBCDIC),
- American Standard Code for Information Interchange (ASCII), and
- Unicode

In the following subsections, we discuss the EBCDIC, ASCII and Unicode coding schemes.

3.8.1 EBCDIC

- The Extended Binary Coded Decimal Interchange Code (EBCDIC) uses 8 bits (4 bits for zone, 4 bits for digit) to represent a symbol in the data.
- EBCDIC allows 28 = 256 combinations of bits.
- 256 unique symbols are represented using EBCDIC code. It represents decimal numbers (0–9), lower case letters (a–z), uppercase letters (A–Z), Special characters, and Control characters (printable and non–printable, e.g., for cursor movement, printer vertical spacing, etc.).
- EBCDIC codes are mainly used in the mainframe computers.

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3.8.2 ASCII

- The American Standard Code for Information Interchange (ASCII) is widely used in computers of all types.
- ASCII codes are of two types—ASCII–7 and ASCII–8.
- *ASCII-7* is a 7-bit standard ASCII code. In ASCII-7, the first 3 bits are the zone bits and the next 4 bits are for the digits. ASCII-7 allows 27 = 128 combinations. 128 unique symbols are represented using ASCII-7. ASCII-7 has been modified by IBM to ASCII-8.
- *ASCII-8* is an extended version of ASCII-7. ASCII-8 is an 8-bit code having 4 bits for zone and 4 bits for the digit. ASCII-8 allows 28 = 256 combinations. ASCII-8 represents 256 unique symbols. ASCII is used widely to represent data in computers.
- The ASCII-8 code represents 256 symbols.
    - Codes 0 to 31 represent control characters (non–printable), because they are used for actions like, Carriage return (CR), Bell (BEL), etc.
    - Codes 48 to 57 stand for numeric 0–9.
    - Codes 65 to 90 stand for uppercase letters A–Z.
    - Codes 97 to 122 stand for lowercase letters a–z.
    - Codes 128 to 255 are the extended ASCII codes.

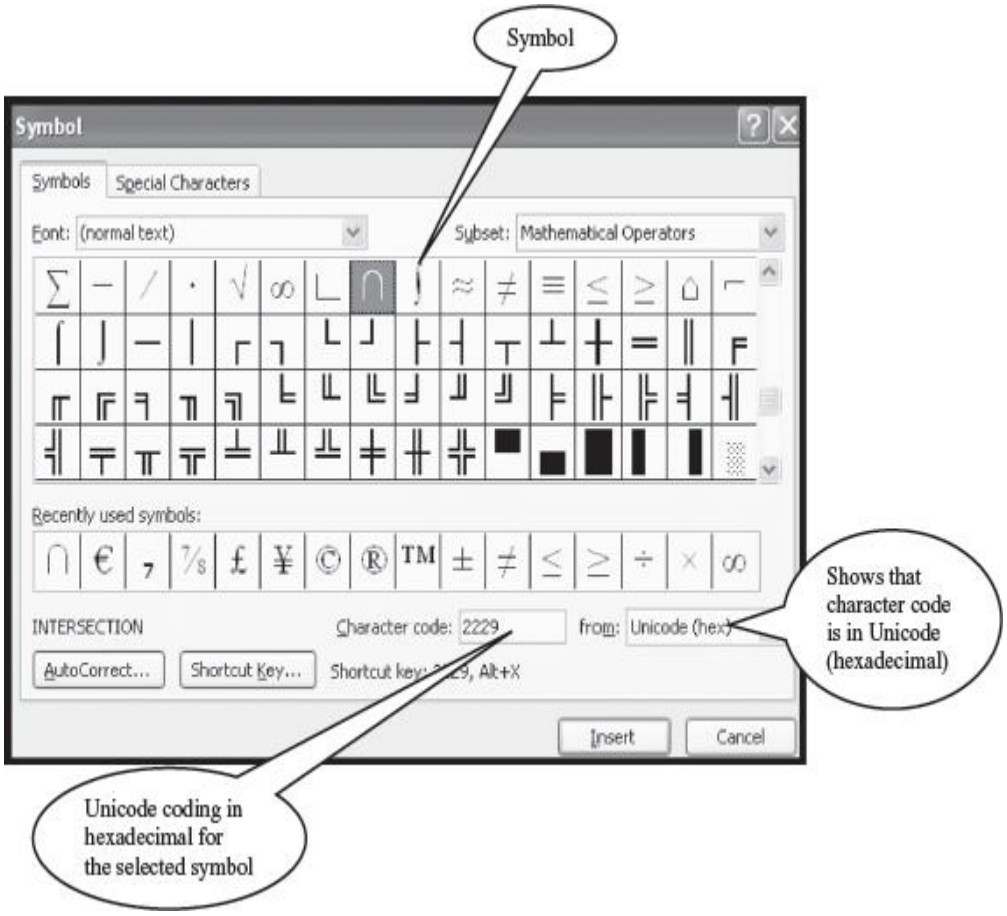
3.8.3 Unicode

- Unicode is a universal character encoding standard for the representation of text which includes letters, numbers and symbols in multi–lingual environments. The Unicode Consortium based in California developed the Unicode standard.
- Unicode uses 32 bits to represent a symbol in the data.
- Unicode allows 232 = 4164895296 (~ 4 billion) combinations.

- Unicode can uniquely represent any character or symbol present in any language like Chinese, Japanese, etc. In addition to the letters; mathematical and scientific symbols are also represented in Unicode codes.
- An advantage of Unicode is that it is compatible with the ASCII–8 codes. The first 256 codes in Unicode are identical to the ASCII-8 codes.
- Unicode is implemented by different character encodings. UTF-8 is the most commonly used encoding scheme. UTF stands for Unicode Transformation Format. UTF-8 uses 8 bits to 32 bits per code.

If you wish to see the Unicode character encoding in MS–Word 2007, do as follows:

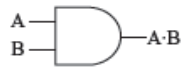
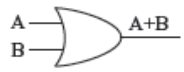
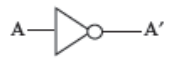
<Insert> <Symbol>. A Symbol dialog box will appear which displays the symbols, and the character codes in a coding scheme, as shown in Figure.

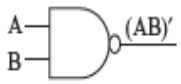
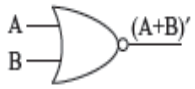
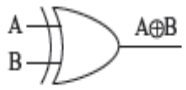
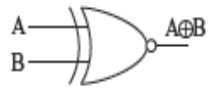


3.9 LOGIC GATES

The information is represented in the computer in binary form. Binary information is represented using signals in two states *off* or on which correspond to 0 or 1, respectively. The manipulation of the binary information is done using logic gates. Logic gates are the hardware electronic circuits which operate on the input signals to produce the output signals. Each logic gate has a unique symbol and its operation is described using algebraic expression. For each gate, the truth table shows the output that will be outputted for the different possible combinations of the input signal. The AND, OR and NOT are the basic logic gates. Some of the basic combination of gates that are widely used are—NAND, NOR, XOR and XNOR.

The following table shows the different logic gates, their symbols, their algebraic function and the truth table for each logic gate. The comments list the features of each logic gate.

Operation	Symbol	Algebraic Function	Comments	Truth Table
AND		X = A.B or X = AB	• Two or more binary inputs • The output is 1 if all the inputs are 1, otherwise the output is 0. • Represented using a multiplication symbol "."	A B A.B 0 0 0 0 1 0 1 0 0 1 1 1
OR		X = A + B	• Two or more binary inputs • The output is 1 if at least one input is 1, otherwise the output is 0. • Represented using a "+"	A B A+B 0 0 0 0 1 1 1 0 1 1 1 1
NOT		A = A′	• One binary input • The output is complement (opposite) of input. If input is 1 output is 0 and if input is 0 output is 1. • Represented using a " ′ "	A A′ 0 1 1 0

Operation	Symbol	Algebraic Function	Comments	Truth Table
NAND		X = (AB)′	• Two or more binary inputs • NAND is complement of AND	A B (A.B)′ 0 0 1 0 1 1 1 0 1 1 1 0
NOR		X = (A + B)′	• Two or more binary inputs • NOR is complement of OR.	A B (A+B)′ 0 0 1 0 1 0 1 0 0 1 1 0
XOR		X = (A ⊕ B)	• Two or more binary inputs • The output is 1 if the odd number of inputs is 1. • Represented using a " ⊕ "	A B (A⊕B) 0 0 0 0 1 1 1 0 1 1 1 0
XNOR		X = (A ⊕ B)′	• Two or more binary inputs • XNOR is complement of XOR.	A B (A⊕B)′ 0 0 1 0 1 0 1 0 0 1 1 1

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SUMMARY

- ✓ *Face value* of a digit is the digit located at that place. The position value of digit is (baseposition). The number is the sum of (face value * baseposition) of all the digits.
- ✓ In computer science, decimal *number system* (base 10), binary number system (base 2), octal number system (base 8), and hexadecimal number system (base 16) concern us.
- ✓ *Decimal number system* has 10 digits—0 to 9, the maximum digit being 9.
- ✓ *Binary number system* has two digits—0 and 1.
- ✓ *Octal number system* consists of eight digits—0 to 7, the maximum digit being 7.
- ✓ *Hexadecimal number system* has sixteen digits—0 to 9, A, B, C, D, E, F, where (A is for 10, B is for 11, C—12, D—13, E—14, F—15). The maximum digit is F, i.e., 15.
- ✓ *Binary arithmetic operations* are the binary addition, subtraction, multiplication and division operations performed on the binary numbers.
- ✓ For any number in base r, there is r's *complement and r—1's complement*. For example, binary numbers can be represented in 1's complement and 2's complement.
- ✓ *Sign bit* is the most significant bit. The sign bit is 1 and 0 for a positive number and negative number, respectively.
- ✓ *Position of binary point* in a binary number is represented using Fixed Point Number Representation and Floating Point Number Representation.
- ✓ In *fixed point representation*, the positive integer binary number is represented with sign bit 0 and magnitude as positive binary number. The negative integer is represented in signed magnitude representation, signed 1 's complement representation and signed 's complement representation.

- ✓ *Addition of two signed binary numbers* requires the positive number to be represented as binary number and negative number to be represented in 's complement form.
- ✓ *Floating point representation* has two parts—Mantissa and Exponent. Mantissa is a signed fixed point number and exponent shows the position of the binary point in the mantissa.
- ✓ *Binary Coding schemes* represent data in a binary form in the computer. ASCII, EBCDIC, and Unicode are the most commonly used binary coding scheme.
- ✓ *EBCDIC* is a 8-bit code with 256 different representations of characters. It is mainly used in mainframe computers.
- ✓ *ASCII-8* is a 8-bit code and allows 256 characters to be represented. ASCII is widely to represent data in computers, internally.
- ✓ *Unicode* is a universal character encoding standard for the representation of text in multi-lingual environments. UTF-8 is the most commonly used encoding.
- ✓ *Logic gate* is the hardware electronic circuit that operates on input signals to produce output signal. AND, OR, NOT, NAND, NOR, XOR and XNOR are some of the logic gates.

QUESTIONS

1. What is the significance of the base of the number?

2. Explain the significance of the face value and position value of a number. Give an example.

3. What is the position value of a digit?

4. The decimal number system is in base ____.

5. The binary number system is in base ____.

6. The octal number system is in base ____.

7. The hexadecimal number system is in base ____.

8. Convert the following decimal numbers into binary, octal and hexadecimal.

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24 , 47, 675, 89, 34.24, 150.64, .98, .29, 24.14, 16.1, 22.33

9. Convert the following binary numbers into decimal numbers.

110000111

110011

1001111

11000001

1100110.1110

11110.0000

01001.0101

1010.10101

11000011.111

11001.1101

100.111

101.0111

10. Perform binary addition on the following binary numbers.

111100, 011011

1001, 1111

0110, 1100

1100, 1010

11. Perform binary subtraction on the following binary numbers.

111000, 011010

1111, 1001

0110, 0010

1100, 1010

12. Represent the following as 8-bit numbers in Fixed Point number representation.

+22

+55

+34

+67

13. Represent the following binary numbers in Floating Point number representation.

    1100.011

    110.001

    11.110

    1010.011

14. Why are binary coding schemes needed?

15. List any four commonly used binary coding schemes.

16. What number of bits is used to represent the following codes—(a) EBCDIC, (b) ASCII-7, and (c) ASCII–8?

17. How many characters can be represented in the following codes—(a) EBCDIC, (b) ASCII-7, and (c) ASCII-8?

18. How is Unicode different from the other Binary coding schemes? (Hint: multilingual, no. of characters)

19. What is UTF-8 character encoding?

20. Name the basic logic gates.

21. Draw the symbols of the following logic gates—(a) AND, (b) OR, (c) NOT, (d) NAND, (e) NOR, (f) XOR, and (g) XNOR.

22. Write the truth table of the following logic gates—(a) AND, (b) OR, (c) NOT, (d) NAND, (e) NOR, (f) XOR, and (g) XNOR.

23. Write the algebraic function of the following logic gates– (a) AND, (b) OR, (c) NOT, (d) NAND, (e) NOR, (f) XOR, and (g) XNOR.

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4. NETWORKS & INTERNET

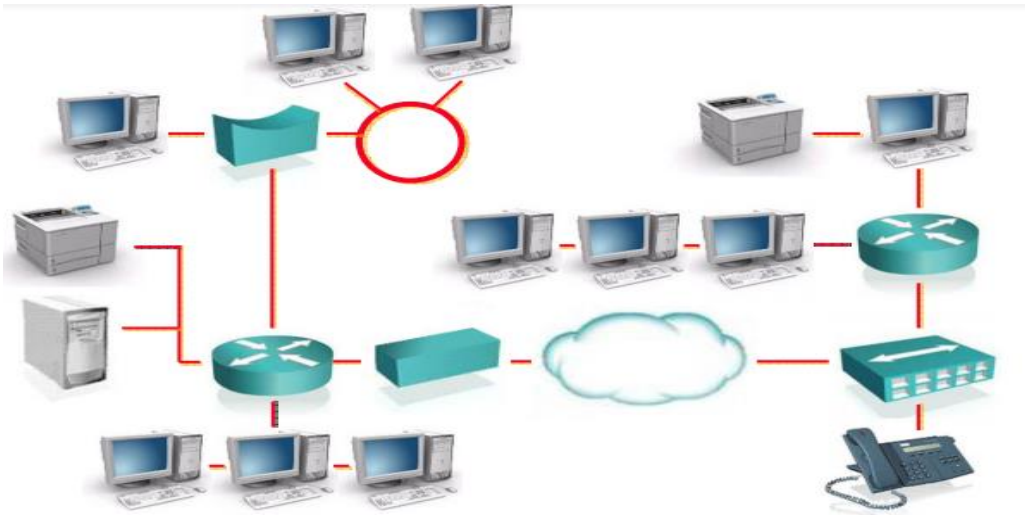
4.1 WHAT IS A COMPUTER NETWORK?

A computer network comprises two or more computers that are connected—either by cables (wired) or Wi-Fi (wireless)—with the purpose of transmitting, exchanging, or sharing data and resources. You build a computer network using hardware (e.g., routers, switches, access points, and cables) and software (e.g., operating systems or business applications).

Geographic location often defines a computer network. For example, a LAN (local area network) connects computers in a defined physical space, like an office building, whereas a WAN (wide area network) can connect computers across continents. The internet is the largest example of a WAN, connecting billions of computers worldwide.

You can further define a computer network by the protocols it uses to communicate, the physical arrangement of its components, how it controls traffic, and its purpose.

Computer networks enable communication for every business, entertainment, and research purpose. The internet, online search, email, audio and video sharing, online commerce, live-streaming, and social networks all exist because of computer networks.



A network is two or more computers (or other electronic devices) that are connected together, usually by cables or Wi-Fi.

Some computer networks will have a server. A server is a powerful computer that often acts as a central hub for services in a network, eg emails, internet access and file storage. Each computer connected to a server is called a client.

A computer that is not connected to a network is called a standalone computer.

4.2 WHAT ARE THE BENEFITS OF A NETWORK?

Using a network allows you to share:

- hardware, such as a printer
- software, allowing multiple users to run the same programs on different computers
- data, so that other people can access shared work and you can access your data from any computer on the network

Networking is critical if you want to use your computer to communicate. Without it you couldn't send an email, a text or an instant message.

We use a huge network on a daily basis, and this is called the internet. Around three billion people use the internet to share data, news and resources, amongst many other things.

4.3 COMPUTER NETWORK TYPES

As networking needs evolved, so did the computer network types that serve those needs. Here are the most common and widely used computer network types:

1. **LAN (local area network):** A LAN connects computers over a relatively short distance, allowing them to share data, files, and resources. For example, a LAN may connect all the computers in an office building, school, or hospital. Typically, LANs are privately owned and managed.

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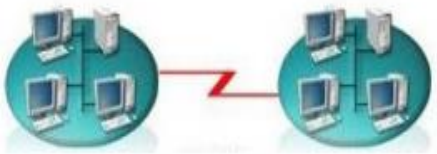
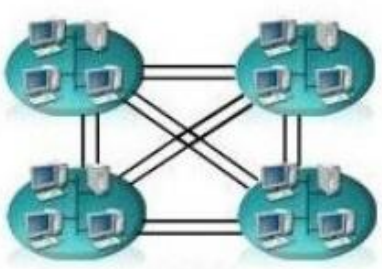
2. **WLAN (wireless local area network):** A WLAN is just like a LAN but connections between devices on the network are made wirelessly.

3. **WAN (wide area network):** As the name implies, a WAN connects computers over a wide area, such as from region to region or even continent to continent. The internet is the largest WAN, connecting billions of computers worldwide. You will typically see collective or distributed ownership models for WAN management.

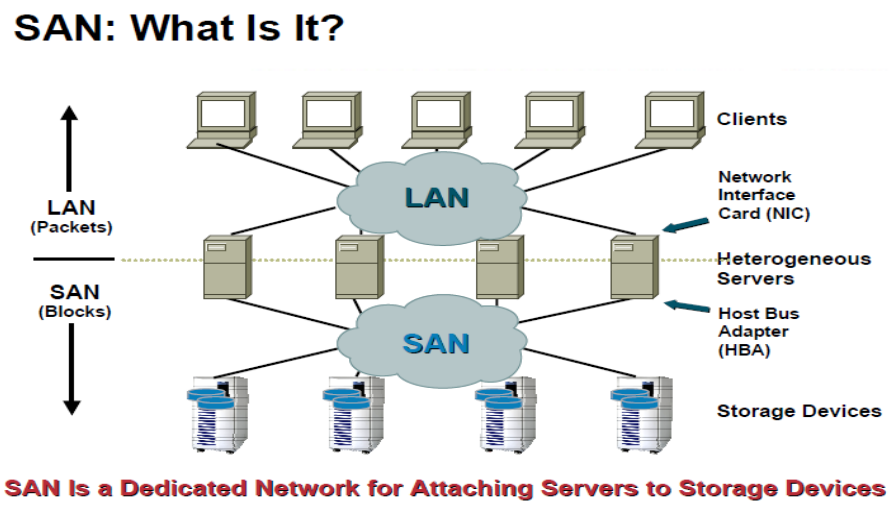
4. **MAN (metropolitan area network):** MANs are typically larger than LANs but smaller than WANs. Cities and government entities typically own and manage MANs.





5. **PAN (personal area network):** A PAN serves one person. For example, if you have an iPhone and a Mac, it's very likely you've set up a PAN that shares and syncs content—text messages, emails, photos, and more—across both devices.

6. **SAN (storage area network):** A SAN is a specialized network that provides access to block-level storage—shared network or cloud storage that, to the user, looks and works like a storage drive that's physically attached to a computer. For more information on how a SAN works with block storage, see our video "Block Storage vs. File Storage" and "Block Storage: A Complete Guide."



4. 4 IMPORTANT TERMS AND CONCEPTS

The following are some common terms to know when discussing computer networking:

- **IP address:** An IP address is a unique number assigned to every device connected to a network that uses the Internet Protocol for communication. Each IP address identifies the device's host network and the location of the device on the host network. When one device sends data to another, the data includes a 'header' that includes the IP address of the sending device and the IP address of the destination device.

- **Nodes:** A node is a connection point inside a network that can receive, send, create, or store data. Each node requires you to provide some form of identification to receive access, like an IP address. A few examples of nodes include computers, printers, modems, bridges, and switches. A node is essentially any network device that can recognize, process, and transmit information to any other network node.

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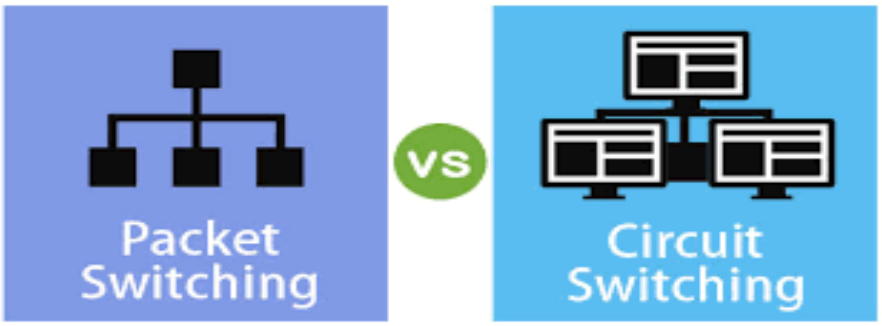
- **Routers:** A router is a physical or virtual device that sends information contained in data packets between networks. Routers analyze data within the packets to determine the best way for the information to reach its ultimate destination. Routers forward data packets until they reach their destination node.

- **Switches:** A switch is a device that connects other devices and manages node-to-node communication within a network, ensuring data packets reach their ultimate destination. While a router sends information

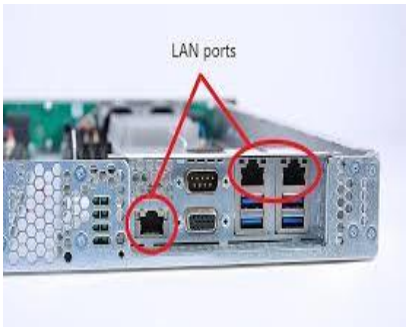


between networks, a switch sends information between nodes in a single network. When discussing computer networks, 'switching' refers to how data is transferred between devices in a network.

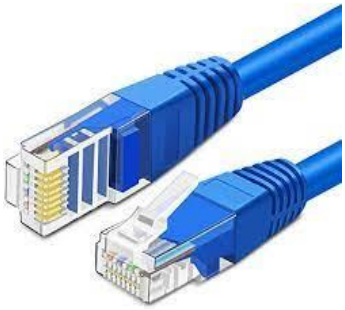
The three main types of switching are as follows:

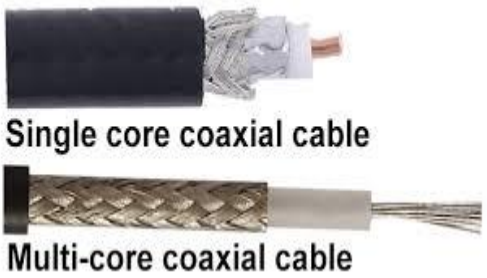
1. **Circuit switching**, which establishes a dedicated communication path between nodes in a network. This dedicated path assures the full bandwidth is available during the transmission, meaning no other traffic can travel along that path.
2. **Packet switching** involves breaking down data into independent components called packets which, because of their small size, make fewer demands on the network. The packets travel through the network to their end destination.
3. **Message switching** sends a message in its entirety from the source node, traveling from switch to switch until it reaches its destination node.

- **Ports:** A port identifies a specific connection between network devices. Each port is identified by a number. If you think of an IP address as comparable to the address of a hotel, then ports are the suites or room numbers within that hotel. Computers use port numbers to determine which application, service, or process should receive specific messages.



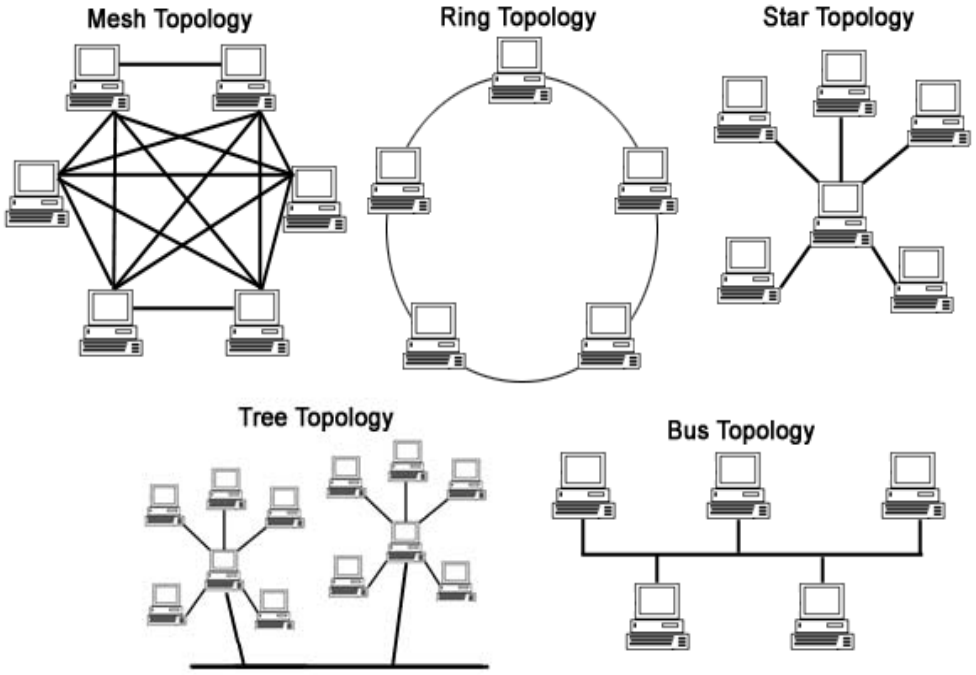
- **Network cable types:** The most common network cable types are Ethernet twisted pair, coaxial, and fiber optic. The choice of cable type depends on the size of the network, the arrangement of network elements, and the physical distance between devices.





4.5 NETWORK TOPOLOGIES AND TYPES OF NETWORKS

The term network topology describes the relationship of connected devices in terms of a geometric graph. Devices are represented as vertices, and their connections are represented as edges on the graph. It describes how many connections each device has, in what order, and it what sort of hierarchy.



Typical network configurations include the bus topology, mesh topology, ring topology, star topology, tree topology and hybrid topology.

4.5.1 Bus topology

Alternatively referred to as line topology, bus topology is a network setup where each computer and network device is connected to a single cable or backbone. Depending on the type of computer network card, a coaxial cable or an RJ-45 network cable is used to connect them together.

Advantages of bus topology

- ✓ It works well when you have a small network.
- ✓ It's the easiest network topology for connecting computers or peripherals in a linear fashion.
- ✓ It requires less cable length than a star topology.

Disadvantages of bus topology

- It can be difficult to identify the problems if the whole network goes down.
- It can be hard to troubleshoot individual device issues.
- Bus topology is not great for large networks.
- Terminators are required for both ends of the main cable.
- Additional devices slow the network down.
- If a main cable is damaged, the network fails or splits into two.

4.5.2 Star topology

Alternatively referred to as a star network, star topology is one of the most common network setups. In this configuration, every node connects to a central network device, like a hub, switch, or computer. The central network device acts as a server and the peripheral devices act as clients. In a star topology setup, either a coaxial or RJ-45 network cable is used, depending on the type of network card installed in each computer. The image shows how this network setup gets its name, as it is shaped like a star.

Advantages of star topology

- ✓ Centralized management of the network, through the use of the central computer, hub, or switch.
- ✓ Easy to add another computer to the network.
- ✓ If one computer on the network fails, the rest of the network continues to function normally.

Disadvantages of star topology

- May have a higher cost to implement, especially when using a switch or router as the central network device.
- The central network device determines the performance and number of nodes the network can handle.

- If the central computer, hub, or switch fails, the entire network goes down and all computers are disconnected from the network.

4.5.3 Ring topology

A ring topology is a network configuration where device connections create a circular data path. Each networked device is connected to two others, like points on a circle. Together, devices in a ring topology are referred to as a ring network

Advantages of a ring topology

- ✓ All data flows in one direction, reducing the chance of packet collisions.
- ✓ A network server is not needed to control network connectivity between each workstation.
- ✓ Data can transfer between workstations at high speeds.
- ✓ Additional workstations can be added without impacting performance of the network.

Disadvantages of a ring topology

- All data being transferred over the network must pass through each workstation on the network, which can make it slower than a star topology.
- The entire network will be impacted if one workstation shuts down.
- The hardware needed to connect each workstation to the network is more expensive than Ethernet cards and hubs/switches.

4.5.4 Mesh topology

A mesh topology is a network setup where each computer and network device is interconnected with one another. This topology setup allows for most transmissions to be distributed even if one of the connections goes down. It is a topology commonly used for wireless networks. Below is a visual example of a simple computer setup on a network using a mesh topology.

Advantages of a mesh topology

- ✓ Manages high amounts of traffic, because multiple devices can transmit data simultaneously.
- ✓ A failure of one device does not cause a break in the network or transmission of data.
- ✓ Adding additional devices does not disrupt data transmission between other devices.

Disadvantages of a mesh topology

- o The cost to implement is higher than other network topologies, making it a less desirable option.
- o Building and maintaining the topology is difficult and time consuming.
- o The chance of redundant connections is high, which adds to the high costs and potential for reduced efficiency.

4.6 INTERNET BASICS

4.6.1 What is the Internet?

The Internet is an increasingly important part of everyday life for people around the world. But if you've never used the Internet before, all of this new information might feel a bit confusing at first.

Throughout this tutorial, we'll try to answer some basic questions you may have about the Internet and how it's used. When you're done, you'll have a good understanding of how the Internet works, how to connect to the Internet, and how to browse the Web.

The Internet is a global network of billions of computers and other electronic devices. With the Internet, it's possible to access almost any information, communicate with anyone else in the world, and do much more.

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You can do all of this by connecting a computer to the Internet, which is also called going online. When someone says a computer is online, it's just another way of saying it's connected to the Internet.

4.6.2 What is the Web?

The World Wide Web—usually called the Web for short—is a collection of different websites you can access through the Internet. A website is made up of related text, images, and other resources. Websites can resemble other forms of media—like newspaper articles or television programs—or they can be interactive in a way that's unique to computers.

The purpose of a website can be almost anything: a news platform, an advertisement, an online library, a forum for sharing images, or an educational site like us!

Once you are connected to the Internet, you can access and view websites using a type of application called a web browser. Just keep in mind that the web browser itself is not the Internet; it only displays websites that are stored on the Internet.

4.6.3 How does the Internet work?

At this point you may be wondering, how does the Internet work? The exact answer is pretty complicated and would take a while to explain. Instead, let's look at some of the most important things you should know.

It's important to realize that the Internet is a global network of physical cables, which can include copper telephone wires, TV cables, and fiber optic cables. Even wireless connections like Wi-Fi and 3G/4G rely on these physical cables to access the Internet.

When you visit a website, your computer sends a request over these wires to a server. A server is where websites are stored, and it works a lot like your

computer's hard drive. Once the request arrives, the server retrieves the website and sends the correct data back to your computer. What's amazing is that this all happens in just a few seconds!

https://www.youtube.com/watch?v=pj63P16kYEQ

4.6.4 The World Wide Web (WWW)

When most people think of the internet, the first thing they think about is the Worldwide W eb. Nowadays, the terms "internet" and "World Wide Web" are often used interchangeably— but they're actually not the same thing.

- The internet is the physical network of computers all over the world.
- The World Wide Web is a virtual network of web sites connected by hyperlinks (or "links"). Web sites are stored on servers on the internet, so the World Wide Web is a part of the internet.

HTML

The backbone of the World Wide Web is made of HTML files, which are specially formatted documents that can contain links, as well as images and other media. All web browsers can read HTML files. In addition to HTML, it's also very common for websites to use technologies like CSS (Cascading Style Sheets) and JavaScript to do more advanced things.

URL

To get to a web page, you can type the URL (Uniform Resource Locator) in a browser. The URL, also known as the web address, tells the browser exactly where to find the page. However, most of the time, people get to a web page by following a link from a different page or by searching for the page with a search engine.

The World Wide Web was created in 1989 by Tim Berners-Lee, a software engineer. Before then, computers could communicate over the internet, but there were no web pages.

A URL has two main components:

- Protocol identifier: For the URL http://example.com, the protocol identifier is http.

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- Resource name: For the URL http://example.com, the resource name is example.com.

An Internet domain name is a unique name of an organization or person on the Internet. The name is combined with a generic top-level domain (gTLD), such as .com or .org. For example, computerlanguage.com is the domain name for the publisher of this encyclopedia. By 2019, there were more than 300 million registered domain names.

Under ICANN's "New gTLD" program, communities, industries and organizations can create their own top-level domain names: **Generic Top-Level Domains**

In 1985, the following generic top-level domains (GTLDs) were created.

Unrestricted GTLDs

.com commercial

.net network oriented

.org non-profit organization

Restricted GTLDs

.edu accredited U.S. educational

.gov U.S. government agencies

.mil U.S. military

.int international treaties (1988)

Advantages of Internet:

Based on a recent survey of Internet uses, the 10 most popular uses of the Internet in descending order of use are:

- ✓ Electronic mail. At least 85% of the inhabitants of cyberspace send and receive e-mail. Some 20 million e-mail messages cross the Internet every week.
- ✓ Research.
- ✓ Downloading files.
- ✓ Discussion groups. These include public groups, such as those on Usenet, and the private mailing lists that Listserv manages.

- ✓ Interactive games. Who hasn't tried to hunt down at least one game?
- ✓ Education and self-improvement. On-line courses and workshops have found yet another outlet.

- ✓ Friendship and dating. You may be surprised at the number of electronic "personals" that you can find on the World Wide Web.
- ✓ Electronic newspapers and magazines. This category includes late-breaking news, weather, and sports. We're likely to see this category leap to the top five in the next several years.
- ✓ Job-hunting. Classified ads are in abundance, but most are for technical positions.

- ✓ Shopping. It's difficult to believe that this category even ranks. It appears that "cybermalls" are more for curious than serious shoppers.
- ✓ Online Booking. Online booking is an astonishing tool on the internet. By this, we can book a train ticket, flight ticket (International and domestic), and you can book a taxi which will pick-up you from your doorstep. Some

online ticket booking sites are www.makemytrip.com, www.goibibo.com, www.kayak.co.in, etc. Online taxi: OLA cabs, Lyft, Gett, UBER, etc.

- ✓ Online Banking. Online banking makes life human being secure and comfortable. Now, anybody does not have to carry hard cash in pocket or suitcase from one place to other because now most of the rights of your bank account are in your hand. You can excess and manage your account while sitting at home or traveling in abroad.

- ✓ Social Networking Social networking sits helps a lot in connecting the world together. On social networking sites, you will get each and everything from informative stuff to entertainment. Social networking is the combination of the many applications and websites including Facebook, WhatsApp, Twitter, Pinterest, Instagram, etc.

Disadvantages of Internet:

On the other side of the coin if we discuss its disadvantages in brief then the following are some common:

- ***A Waste of Time:***

Most people argue that spending a lot of time using the internet is bad which leads to obesity in the young generation. In the contemporary world, people also say that the internet is not necessary for life and life would be easier without it.

- ***Not Safe Place for Children:***

If children are allowed to use the internet, then parents become worried if they are spending much time on the internet. Pornography and unethical communities are available. So, one can say that the internet is not a safe place for children because there are different tools available who can bypass 'parental protection'. Also, children who use the internet are becoming addicted to it which is again very dangerous.

- ***Privacy Exposure:***

Because of the hacker's community now it's very easy to decipher someone's chat or email messages. As we know data is transmitted in the form of packets, hackers sniff that packets and easily reconstruct.

- ***Money Frauds:***

With the introduction of online business, virtual shops, and credit card usage; now it becomes very easy to buy things without going into the market. Besides legitimate sites there are some other Social Media Advertising sites that make frauds of money, these sites try to get your personal information, credit card details, and even pin code. Once they get this information you can easily become a victim of money frauds.

- ***Viruses/Malware:***

Often our systems get infected from viruses and ultimately damage our important data which is difficult to recover. These viruses are transported via the internet, CDs, and USBs. Our computer can become totally out of order.

- ***Online Threatening or Harassment:***

If someone manages to get your personal IDs or email address then it becomes easier to harass in chat rooms, online messages, and through emails.

In the end, the internet has its own advantages and disadvantages, but its advantages are extremely high. It simply making lives easier, but we should not forget about the disadvantage it may bring.

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4.7 E-MAIL

Short for electronic mail, e-mail or email is information stored on a computer that is exchanged between two users over telecommunications. More plainly, e-mail is a message that may contain text, files, images, or other attachments sent through a network to a specified individual or group of individuals.

The first e-mail was sent by Ray Tomlinson in 1971. Tomlinson sent the e-mail to himself as a test e-mail message, containing the text "something like QWERTYUIOP." However, despite sending the e-mail to himself, the e-mail message was still transmitted through ARPANET.

By 1996, more electronic mail was being sent than postal mail

E-mail address breakdown

support@computerhope.com

The first portion of all e-mail addresses, the part before the @ symbol, contains the alias, user, group, or department of a company. In our above example, support is the Technical Support department at Computer Hope.

Next, the @ (at sign) is a divider in the e-mail address; it's required for all SMTP e-mail addresses since Ray Tomlinson sent the first message.

Finally, computerhope.com is the domain name that the user belongs. The .com is the TLD (top-level domain) for our domain.

Online e-mail

An alternative way of sending and receiving e-mail (and the more popular solution for most people) is an online e-mail service or webmail. Examples include Hotmail (now Outlook.com), Gmail, and Yahoo Mail. Many of the online e-mail services, including the ones we mentioned, are free or have a free account option.

Advantages of e-mail

There are many advantages of e-mail and the usage of e-mail versus postal mail. Some of the main advantages are listed below.

- ✓ Free delivery - Sending an e-mail is virtually free, outside the cost of Internet service. There is no need to buy a postage stamp to send a letter.
- ✓ Global delivery - E-mail can be sent to nearly anywhere around the world, to any country.
- ✓ Instant delivery - An e-mail can be instantly sent and received by the recipient over the Internet.
- ✓ File attachment - An e-mail can include one or more file attachments, allowing a person to send documents, pictures, or other files with an e-mail.
- ✓ Long-term storage - E-mails are stored electronically, which allows for storage and archival over long periods of time.
- ✓ Environmentally friendly - Sending an e-mail does not require paper (paperless), cardboard, or packing tape, conserving paper resources.

There are many e-mail clients (those that are software-based, not online) available for users today. The following list contains some of the most popular clients, and some of these are free to use.

Mozilla Thunderbird,Gmail

Microsoft Outlook, Mail for Windows 10

YAHOO, eM Client

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5. ARTIFICIAL INTELLIGENCE

5.1 WHAT IS AI?

Artificial Intelligence (AI) is a branch of science which deals with helping machines find solutions to complex problems in a more human-like fashion.

This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way.

A more or less flexible or efficient approach can be taken depending on the requirements established, which influences how artificial the intelligent behavior appears.

Artificial intelligence can be viewed from a variety of perspectives.

From the perspective of intelligence⎫ artificial intelligence is making machines "intelligent" -- acting as we would expect people to act.

- The inability to distinguish computer responses from human responses is called the Turing test.
- Intelligence requires knowledge
- Expert problem solving - restricting domain to allow including significant relevant knowledge

From a business perspective AI is a set of very powerful tools, and methodologies for using those tools to solve business problems.

From a programming perspective, AI includes the study of symbolic⎫ programming, problem solving, and search.

- Typically, AI programs focus on symbols rather than numeric processing.
- Problem solving - achieve goals.

- Search - seldom access a solution directly. Search may include a variety of techniques.

- AI programming languages include:

➢ **LISP**, developed in the 1950s, is the early programming language strongly associated with AI. LISP is a functional programming language with procedural extensions. LISP (LISt Processor) was specifically designed for processing heterogeneous lists -- typically a list of symbols. Features of LISP are run- time type checking, higher order functions (functions that have other functions as parameters), automatic memory management (garbage collection) and an interactive environment

➢ **The second language strongly associated with AI is PROLOG**. PROLOG was developed in the 1970s. PROLOG is based on first order logic. PROLOG is declarative in nature and has facilities for explicitly limiting the search space

➢ **Object-oriented languages** are a class of languages more recently used for AI programming. Important features of object-oriented languages include: concepts of objects and messages, objects bundle data and methods for manipulating the data, sender specifies what is to be done receiver decides how to do it, inheritance (object hierarchy where objects inherit the attributes of the more general class of objects). Examples of object-oriented languages are Smalltalk, Objective C, C++. Object oriented extensions to LISP (CLOS - Common LISP Object System) and PROLOG (L&O - Logic & Objects) are also used.

Artificial Intelligence is a new electronic machine that stores large amount of information and process it at very high speed

The computer is interrogated by a human via a teletype It passes if the human cannot tell if there is a computer or human at the other end

The ability to solve problems

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It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence

Today, the amount of data that is generated, by both humans and machines, far outpaces humans' ability to absorb, interpret, and make complex decisions based on that data. Artificial intelligence forms the basis for all computer learning and is the future of all complex decision making. As an example, most humans can figure out how to not lose at tic-tac-toe (noughts and crosses), even though there are 255,168 unique moves, of which 46,080 end in a draw. Far fewer folks would be considered grand champions of checkers, with more than 500 x 1018, or 500 quintillion, different potential moves. Computers are extremely efficient at calculating these combinations and permutations to arrive at the best decision. AI (and its logical evolution of machine learning) and deep learning are the foundational future of business decision making.

5.2 IMPORTANCE OF ARTIFICIAL INTELLIGENCE

Below we are going to read about the vast importance of artificial intelligence:

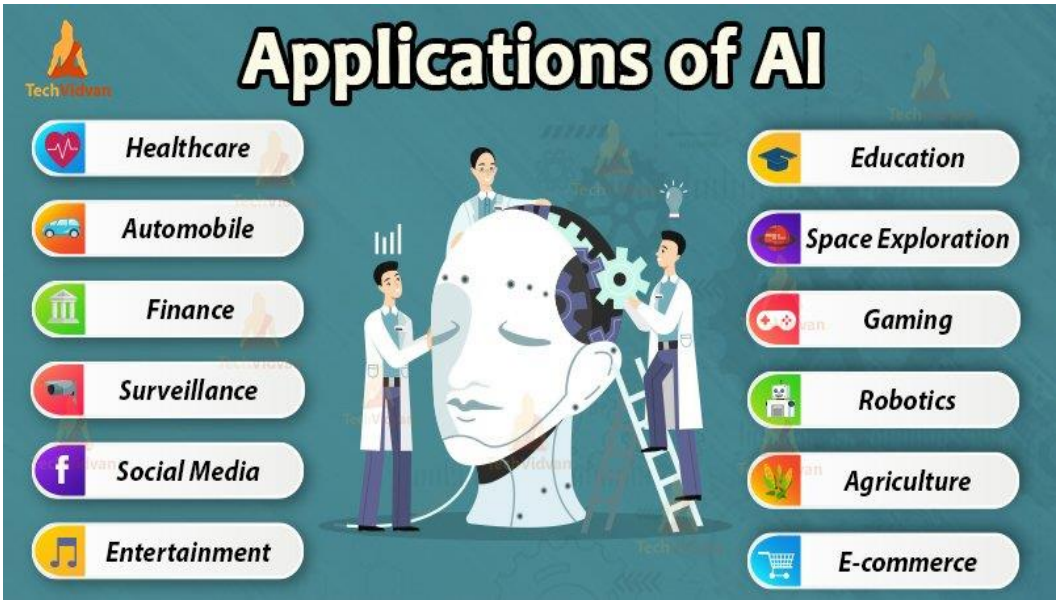
- The importance of artificial intelligence and its subsequent components have been known for quite a long time now. They are being looked upon as tools and techniques to make this world a better place. And it's just not that you have to go to these fancy tech gadgets to be able to use them. You can simply look around, and I am sure most of your tasks are made smooth by artificial intelligence.

- Its importance lies in making our lives easier. These technologies are a great asset to humans and are programmed to reduce the human effort as much as possible. They tend to possess the capability to work in an automated fashion. Therefore, manual intervention is the last thing that could be asked for or seen while operating parts associated with this technology.

- These machines tend to speed up your tasks and processes along with a guaranteed level of precision and accuracy, and therefore this is what makes them a useful and important tool. Apart from making the world an

error-free place by their simple and everyday techniques, these technologies and applications are not only related to our general and everyday lives. It is also impacting and holds importance for other domains as well.

5.3 THE APPLICATIONS OF AI



Artificial intelligence is used in a variety of ways in today's society. It is becoming increasingly important in today's world because it can efficiently handle complicated problems in a variety of areas, including healthcare, entertainment, banking, and education. Our daily lives are becoming more comfortable and efficient as a result of artificial intelligence.

Here are some of the Artificial Intelligence Applications that we are going to understand in depth.

5.3.1 Healthcare:

Many businesses and medical care institutions are turning to artificial intelligence (AI) to save our lives. There are numerous examples of how artificial intelligence in healthcare has benefited patients around the world. Let's understand some of the uses of AI in subdomains of Healthcare.

- **Administration:** To reduce human errors and increase productivity, AI systems are assisting with normal, day-to-day administrative activities like scheduling meetings, maintaining organized file systems. NLP(Natural Language Processing) is used to transcribe medical notes and to help organize patient information so that clinicians can read it more easily.

- **Assisted Diagnosis:** AI can now interpret MRI scans to check for tumors and other harmful growths at a tenfold faster rate than radiologists can, with a much narrower margin of error, thanks to computer vision and convolutional neural networks.

- **Robotic Surgery:** Robotic operations have a very small margin of error and can operate 24 hours a day, seven days a week without becoming weary. They are less intrusive than previous procedures because they work with such precision, potentially reducing the amount of time patients spend in the hospital recovering.

- **Health Monitoring:** The status of a person's health is a continuous process that is determined by the various levels of their vital statistics. With wearable devices becoming more mainstream, this data is no longer on tap, waiting to be analyzed and turned into meaningful insights. There are numerous life-saving uses here since vital indicators have the ability to forecast health variations even before the patient is aware.

5.3.2 E-Commerce:

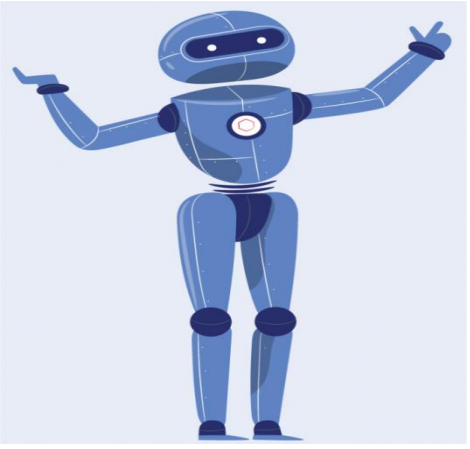
AI is giving the e-commerce industry a competitive advantage, and it is becoming increasingly demanded in the market. Shoppers can use AI to find related products in their preferred size, color, or brand. Let's understand some applications of AI in E-commerce.

- **Personalized Shopping:** Artificial Intelligence (AI) is used to construct recommendation engines that help you engage with end customers more effectively. These suggestions are based on their previous browsing behavior, preferences, and interests. It aids in the improvement of your consumer interaction as well as brand loyalty.

- **AI-powered assistants:** Virtual shopping assistants and chatbots aid in the enhancement of the online buying experience. Natural Language Processing (NLP) is used to make the dialogue sound more human and personal. Furthermore, these assistants can interact with your consumers in real-time.

- **Fraud Detection and prevention:** Two of the most serious difficulties that E-Commerce businesses face are credit card fraud and fraudulent reviews. By taking into account usage trends, AI can help to lower the risk of credit card fraud. Many buyers choose to acquire a product or service based on what other people have said about it. Artificial intelligence can assist in detecting and dealing with fraudulent reviews.

5.3.3 Robotics:



Even before AI became a reality, the field of robots was progressing. Artificial intelligence is currently assisting robotics in developing more efficient robots. AI-enabled robots have found use in a variety of verticals and industries, particularly in the manufacturing and packaging industries. Artificial Intelligence, or AI,

provides robots with a computer vision that allows them to navigate, sense, and react appropriately. Machine learning, which is a part of computer programming and AI, is how robots learn to do tasks from humans. Humanoid Robots are the best examples of AI in robotics, recently the intelligent Humanoid robot named Erica and Sophia has been developed which can talk and behave like humans. Here are a few examples of AI robot applications:

- Manufacturing
- Transport
- Surgery
- Space Exploration

5.3.4 Finance:

Artificial intelligence is changing the way we deal with money in finance. From credit decisions to quantitative trading and financial risk management, AI is assisting the financial industry in streamlining and optimizing procedures. Artificial Intelligence provides features like risk assessment, fraud detection, and management, financial advisory services, Automated trading in Finance.

Here are a few Finance AI Examples:

- AI in personal Finance
- AI in Consumer Finance
- AI in Corporate Finance

5.3.5 Facial Recognition:

Face recognition, for example, is an application of AI that focuses on learning and recognizing patterns that lead to quick and efficient outputs.

Facial Recognition is a type of technology that maps and stores an individual's facial traits as a face print. To validate one's identification, the software compares a live taken image to a stored facial print using deep learning techniques.

The backbones of this technology are image processing and machine learning. Face recognition has gotten a lot of interest from researchers because of the human actions that can be found in numerous security applications including airports, criminal detection, face tracking, forensics, and so on. Face biometrics can be less intrusive than other biometric qualities such as palm print, iris, fingerprint, and so on.

So, when you take a selfie and register it for facial recognition, your phone learns a face recognition algorithm, and the next time you log in without typing a password, your phone unlocks itself using only your imagination. Other than smartphones, facial recognition is utilized for security and privacy purposes in airports, offices, and other public places.

5.3.6 Marketing:

Artificial intelligence (AI) applications are also widely used in E-commerce marketing. Artificial intelligence (AI) marketing makes automated decisions based on data collection, analysis, and further observations of audience or economic patterns that may influence marketing efforts. AI is frequently utilized in marketing campaigns where speed is critical. AI systems learn how to effectively engage with customers based on data and customer profiles, then give them personalized messages at the perfect time without the need for marketing team intervention, ensuring optimal productivity. Here are some points explaining how AI used in marketing: -

- With the use of behavioral analysis, pattern recognition, and other AI tools, marketers can deliver highly targeted and personalized ads. It also aids in retargeting viewers at the appropriate time, ensuring greater outcomes and a reduction in emotions of distrust and frustration.
- Gmail and Google Docs employ AI in Smart Compose to read what you're typing, comprehend it, and suggest what to type next, as an example of applying AI in marketing.
- AI can collect and track real-time tactical data, allowing marketers to make decisions right now rather than waiting until the campaign is over.

They may decide what to do next based on data-driven reports, resulting in better and more objective decisions.

5.3.7 Social Media:

Social networking firms use artificial intelligence to analyze large amounts of data to determine what's trending, different hashtags, and patterns. This research aids in the comprehension of user behavior.

Artificial intelligence can monitor unstructured user comments using a variety of techniques to provide a tailored experience and detect crises. The technology can also help with content creation by evaluating various activities as well as demographics.

Let's see how some popular social media websites or apps use Artificial Intelligence:-

- **Instagram:** On Instagram, AI takes into account your interests and the accounts you follow to select which posts appear in your Explore tab.
- **Face book(meta):** Artificial Intelligence is being employed, as well as a technique is known as Deep Text. Facebook can better interpret discussions using this technology. It may be used to automatically translate posts between languages.
- **Twitter:** Twitter uses AI for fraud detection, propaganda removal, and hateful content removal. Twitter also uses AI to suggest tweets to users depending on the types of tweets they engage with.

6. COMPUTER VIRUSES

6.1 COMPUTER VIRUS

A computer virus is a malicious program that self-replicates by copying itself to another program. In other words, the computer virus spreads by itself into other executable code or documents. The purpose of creating a computer virus is to infect vulnerable systems, gain admin control and steal user sensitive data. Hackers design computer viruses with malicious intent and prey on online users by tricking them.

One of the ideal methods by which viruses spread is through emails – opening the attachment in the email, visiting an infected website, clicking on an executable file, or viewing an infected advertisement can cause the virus to spread to your system. Besides that, infections also spread while connecting with already infected removable storage devices, such as USB drives.

It is quite easy and simple for the viruses to sneak into a computer by dodging the defense systems. A successful breach can cause serious issues for the user such as infecting other resources or system software, modifying or deleting key functions or applications and copy/delete or encrypt data.

6.2 HOW DOES A COMPUTER VIRUS OPERATE?

A computer virus operates in two ways. The first kind, as soon as it lands on a new computer, begins to replicate. The second type plays dead until the trigger kick starts the malicious code. In other words, the infected program needs to run

to be executed. Therefore, it is highly significant to stay shielded by installing a robust antivirus program.

Of late, the sophisticated computer virus comes with evasion capabilities that help in bypassing antivirus software and other advanced levels of defenses. The primary purpose can involve stealing passwords or data, logging keystrokes, corrupting files, and even taking control of the machine.

Subsequently, the polymorphic malware development in recent times enables the viruses to change its code as it spreads dynamically. This has made the virus detection and identification very challenging.

6.3 HOW DOES A COMPUTER VIRUS ATTACK?

Once a virus has successfully attached to a program, file, or document, the virus will lie dormant until circumstances cause the computer or device to execute its code. In order for a virus to infect your computer, you have to run the infected program, which in turn causes the virus code to be executed.

This means that a virus can remain dormant on your computer, without showing major signs or symptoms. However, once the virus infects your computer, the virus can infect other computers on the same network. Stealing passwords or data, logging keystrokes, corrupting files, spamming your email contacts, and even taking over your machine are just some of the devastating and irritating things a virus can do.

While some viruses can be playful in intent and effect, others can have profound and damaging effects. This includes erasing data or causing permanent damage to your hard disk. Worse yet, some viruses are designed with financial gains in mind.

6.4 HOW DO COMPUTER VIRUSES SPREAD?

In a constantly connected world, you can contract a computer virus in many ways, some more obvious than others. Viruses can be spread through email and text message attachments, Internet file downloads, and social media scam links. Your mobile devices and smartphones can become infected with mobile viruses through shady app downloads. Viruses can hide disguised as attachments of

socially shareable content such as funny images, greeting cards, or audio and video files.

To avoid contact with a virus, it's important to exercise caution when surfing the web, downloading files, and opening links or attachments. To help stay safe, never download text or email attachments that you're not expecting, or files from websites you don't trust.

6.5 WHAT ARE THE SIGNS OF A COMPUTER VIRUS?

A computer virus attack can produce a variety of symptoms. Here are some of them:

- Frequent pop-up windows. Pop-ups might encourage you to visit unusual sites. Or they might prod you to download antivirus or other software programs.
- Changes to your homepage. Your usual homepage may change to another website, for instance. Plus, you may be unable to reset it.
- Mass emails being sent from your email account. A criminal may take control of your account or send emails in your name from another infected computer.
- Frequent crashes. A virus can inflict major damage on your hard drive. This may cause your device to freeze or crash. It may also prevent your device from coming back on.
- Unusually slow computer performance. A sudden change of processing speed could signal that your computer has a virus.
- Unknown programs that start up when you turn on your computer. You may become aware of the unfamiliar program when you start your computer. Or you might notice it by checking your computer's list of active applications.
- Unusual activities like password changes. This could prevent you from logging into your computer.

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6.6 HOW TO HELP PROTECT AGAINST COMPUTER VIRUSES?

How can you help protect your devices against computer viruses? Here are some of the things you can do to help keep your computer safe.

- Use a trusted antivirus product, such as Norton Antivirus Basic, and keep it updated with the latest virus definitions. Norton Security Premium offers additional protection for even more devices, plus backup.
- Avoid clicking on any pop-up advertisements.
- Always scan your email attachments before opening them.
- Always scan the files that you download using file sharing programs.

6.7 WHAT ARE THE DIFFERENT TYPES OF COMPUTER VIRUSES?

1. Boot sector virus

This type of virus can take control when you start — or boot — your computer. One way it can spread is by plugging an infected USB drive into your computer.

2. Web scripting virus

This type of virus exploits the code of web browsers and web pages. If you access such a web page, the virus can infect your computer.

3. Browser hijacker

This type of virus "hijacks" certain web browser functions, and you may be automatically directed to an unintended website.

4. Resident virus

This is a general term for any virus that inserts itself in a computer system's memory. A resident virus can execute anytime when an operating system loads.

5. Direct action virus

This type of virus comes into action when you execute a file containing a virus. Otherwise, it remains dormant.

6. Polymorphic virus

A polymorphic virus changes its code each time an infected file is executed. It does this to evade antivirus programs.

7. File infector virus

This common virus inserts malicious code into executable files — files used to perform certain functions or operations on a system.

8. Multipartite virus

This kind of virus infects and spreads in multiple ways. It can infect both program files and system sectors.

9. Macro virus

Macro viruses are written in the same macro language used for software applications. Such viruses spread when you open an infected document, often through email attachments.

6.8 HOW TO REMOVE COMPUTER VIRUSES

You can take two approaches to removing a computer virus. One is the manual do-it-yourself approach. The other is by enlisting the help of a reputable antivirus program.

Want to do it yourself? There can be a lot of variables when it comes to removing a computer virus. This process usually begins by doing a web search. You may be asked to perform a long list of steps. You'll need time and probably some expertise to complete the process.

If you prefer a simpler approach, you can usually remove a computer virus by using an antivirus software program. For instance, Norton AntiVirus Basic can remove many infections that are on your computer. The product can also help protect you from future threats.

Separately, Norton also offers a free, three-step virus clean-up plan. Here's how it works.

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- Run a free Norton Security Scan to check for viruses and malware on your devices. Note: It does not run on Mac OS.
- Use Norton Power Eraser's free virus and malware removal tool to destroy existing viruses. Need help? A Norton tech can assist by remotely accessing your computer to track down and eliminate most viruses.
- Install up-to-date security software to help prevent future malware and virus threats.

6.9 CATEGORIES OF VIRUSES

Not all computer viruses behave, replicate, or infect the same way. There are several different categories of viruses and malware. Below I list and discuss some of the most common types of computer viruses.

Trojan Horse:

A Trojan horse program has the appearance of having a useful and desired function. While it may advertise its activity after launching, this information is not apparent to the user beforehand. Secretly the program performs other, undesired functions. A Trojan Horse neither replicates nor copies itself but causes damage or compromises the security of the computer. A Trojan Horse must be sent by someone or carried by another program and may arrive in the form of a joke program or software of some sort. The malicious functionality of a Trojan Horse may be anything undesirable for a computer user, including data destruction or compromising a system by providing a means for another computer to gain access, thus bypassing normal access controls.

Worms:

A worm is a program that makes and facilitates the distribution of copies of itself; for example, from one disk drive to another, or by copying itself using email or another transport mechanism. The worm may do damage and compromise the security of the computer. It may arrive via exploitation of a system vulnerability or by clicking on an infected e-mail.

Boot sector Virus:

A virus which attaches itself to the first part of the hard disk that is read by the computer upon boot up. These are normally spread by floppy disks.

Macro Virus:

Macro viruses are viruses that use another application's macro programming language to distribute themselves. They infect documents such as MS Word or MS Excel and are typically spread to other similar documents.

Memory Resident Viruses:

Memory Resident Viruses reside in a computers volitale memory (RAM). They are initiated from a virus which runs on the computer and they stay in memory after it's initiating program closes.

Rootkit Virus:

A rootkit virus is an undetectable virus which attempts to allow someone to gain control of a computer system. The term rootkit comes from the linux administrator root user. These viruses are usually installed by trojans and are normally disguised as operating system files.

Polymorphic Viruses:

A polymorphic virus not only replicates itself by creating multiple files of itself, but it also changes it's digital signature every time it replicates. This makes it difficult for less sophisticated antivirus software to detect.

6.10 ANTIVIRUS

6.10.1 Definition

Software that is created specifically to help detect, prevent and remove malware (malicious software). Antivirus is a kind of software used to prevent, scan, detect and delete viruses from a computer. Once installed, most antivirus software runs automatically in the background to provide real-time protection against virus attacks. Comprehensive virus protection programs help protect your files and

hardware from malware such as worms, Trojan horses and spyware, and may also offer additional protection such as customizable firewalls and website blocking.

6.10.2 Antivirus programs and computer protection software

Antivirus programs and computer protection software are designed to evaluate data such as web pages, files, software and applications to help find and eradicate malware as quickly as possible. Most provide real-time protection, which can protect your devices from incoming threats; scan your entire computer regularly for known threats and provide automatic updates; and identify, block and delete malicious codes and software. Because so many activities are now conducted online and new threats emerge continuously, it's more important than ever to install a protective antivirus program. Fortunately, there are a number of excellent products on the market today to choose from.

6.10.3 How does antivirus work?

Antivirus software begins operating by checking your computer programs and files against a database of known types of malware. Since new viruses are constantly created and distributed by hackers, it will also scan computers for the possibility of new or unknown type of malware threats.

Typically, most programs will use three different detection devices: specific detection, which identifies known malware; generic detection, which looks for known parts or types of malware or patterns that are related by a common codebase; and heuristic detection, which scans for unknown viruses by identifying known suspicious file structures. When the program finds a file that contains a virus, it will usually quarantine it and/or mark it for deletion, making it inaccessible and removing the risk to your device.

Several different companies build antivirus software and what each offer can vary but all perform some essential functions:

1. Scan specific files or directories for any malware or known malicious patterns
2. Allow you to schedule scans to automatically run for you

3. Allow you to initiate a scan of a particular file or your entire computer, or of a CD or flash drive at any time.
4. Remove any malicious code detected –sometimes you will be notified of an infection and asked if you want to clean the file, other programs will automatically do this behind the scenes.
5. Show you the 'health' of your computer
6. Always be sure you have the best, up-to-date security software installed to protect your computers, laptops, tablets, and smartphones.

6.10.4 How Does Antivirus Software Work?

Many antivirus software programs still download malware definitions straight to your device and scan your files in search of matches. But since, as we mentioned, most malware regularly morphs in appearance to avoid detection, Webroot works differently. Instead of storing examples of recognized malware on your device, it stores malware definitions in the cloud. This allows us to take up less space, scan faster, and maintain a more robust threat library.

6.10.5 Free vs Paid Antivirus Software

From banking to baby photos, so much of our business and personal data live on our devices. If it were stored physically, paying for a security solution would be a no-brainer. Unfortunately, we often expect our online data to remain secure without lifting a finger or spending a cent. Companies claiming to do it for free are partly responsible for the confusion, to be sure. But consumers should insist on features like identity theft protection, mobile security, and support options when it comes to their data security, too—features usually lacking with free solutions.

https://www.youtube.com/watch?v=4FlQBMPfuks

6.10.6 The 5 Best Antivirus Programs

With millions of active viruses and malicious programs costing the global economy billions of dollars each year, it's no surprise that there are numerous

antivirus programs available on the market. They differ in terms of price, the platform they are designed for, functionality, as well as added features.

Some of the best antivirus programs available right now include the following:

1. **Bitdefender**

Bitdefender Total Security is a comprehensive security suite that provides optimal protection against viruses and all types of malicious software. Compatible with the four major operating systems and smart homes, this user-friendly antivirus software also includes a free VPN with a 200MB daily limit, parental controls, webcam protection, a password manager, and a tool specifically designed to fight ransomware. This security suite is very competitively priced and will provide 24/7 protection for up to five devices.

2. **Norton**

Symantec's Norton has been around for almost three decades and is without a doubt one of the most recognizable names in cybersecurity. Its security software suite Norton Security Premium is compatible with all four major platforms as well as smart homes and comes with a variety of excellent features. Although it doesn't include a free VPN service, it offers parental controls and a whopping 25GB of online storage space. This is great for owners of multiple gadgets, as one license protects up to 10 devices.

3. **Panda**

Panda is another excellent antivirus program that offers excellent protection from all known cyber threats. Known for its fast performance, this antivirus software is only compatible with Windows, macOS, and Android. Despite not supporting iOS, the suite comes with a VPN service with a 150MB daily limit, a password manager, parental controls, and a standalone USB antivirus program. Designed to provide protection for up to five devices, Panda Antivirus also includes a full Android malware scanner.

4. **McAfee LiveSafe**

McAfee LiveSafe is unique in that a single license is valid for an unlimited amount of devices. Compatible with all four major operating systems, this security suite

provides superior malware protection for Windows and Android-powered machines without affecting their performance. Although the parental control function is not as advanced as the competition, the inclusion of McAfee's True Key password manager more than makes up for it. Equipped with facial recognition functionality, it will keep all your login data extra-safe.

5. **BullGuard**

Another security software suite designed primarily for Windows and Android, BullGuard offers a high level of antivirus and anti-malware protection without slowing down your computer. Although there's no VPN included in the package, there are plenty of bells and whistles here, including a game booster, cloud backup, parental control, and safe browsing functionality. However, macOS users can only run antivirus scans, while the suite is incompatible with iOS. A single license is valid for up to five devices.