

Computer system:

is an integrated form of different components that work together to give a desirable result. It has different components and each works for a specific purpose; however, they generate a common result as required by the user.

Characteristic of computer system:

1-**Speed:** A computer works with much higher speed and accuracy compared to humans while performing mathematical calculations. Computers can process millions (1,000,000) of instructions per second. The time taken by computers for their operations is microseconds and nanoseconds.

2- **Accuracy:** Computers perform calculations with 100% accuracy. Errors may occur due to data inconsistency or inaccuracy.

3- **Reliability:** A computer is reliable as it gives consistent results for a similar set of data i.e., if we give the same set of input any number of times, we will get the same result.

4- **Automation:** Computer performs all the tasks automatically i.e. it performs tasks without manual intervention.

5-**Memory:** A computer has built-in memory called primary memory where it stores data, and secondary storage are removable devices such as CDs, pen drives, etc., which are also used to store data.

Components of Computer System :

The computer system consists of two basic components:

A- Hardware

The hardware components of a computer system are the physical components such as the electronic and mechanical parts. The major hardware components of a computer system are as in figure 1:

The computer hardware components are:

- 1- Input unit.
- 2- Central Processing Unit (CPU).
- 3- Memory.
- 4- Output unit.

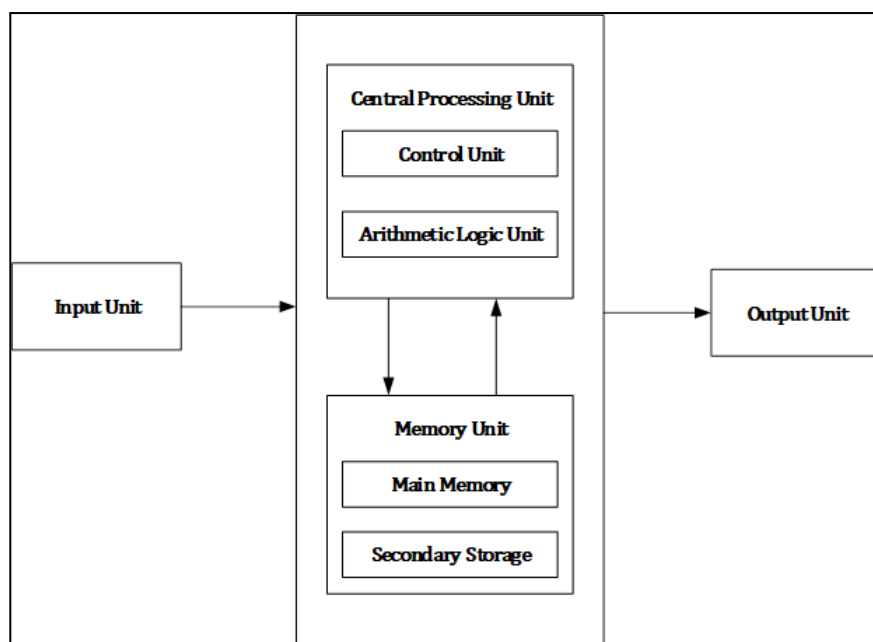


Figure 1 computer hardware components

1-Input unit :

Input devices consist of any devices that users need in order to give instructions to a computer. Essentially input devices act as the medium for sending data to a computer so that users can interact with and control it. There many examples of input devices:

1- Keyboard

The keyboard is a basic input device that is used to enter data into a computer or any other electronic device by pressing keys. It has different sets of keys for letters, numbers, characters, and functions. Keyboards are connected to a computer through USB or a Bluetooth device for wireless communication.

2- Mouse

The mouse is a hand-held input device which is used to move cursor or pointer across the screen. It is designed to be used on a flat surface and generally has left and right buttons and a scroll wheel between them.

Laptop computers come with a touchpad that works as a mouse. It lets you control the movement of cursor or pointer by moving your finger over the touchpad.

Early mouse had a rollerball integrated as a movement sensor underneath the device. Modern mouse devices come with optical technology that controls cursor movements by a visible or invisible light beam. A mouse is connected to a computer through different ports depending on the type of computer and type of a mouse.

3-Scanner

The scanner uses the pictures and pages of text as input. It scans the picture or a document. The scanned picture or document is then converted into a digital format or file and is displayed on the screen as an output. It uses optical character recognition techniques to convert images into digital ones.

4-joystick

A joystick is also a pointing input device like a mouse. It is made up of a stick with a spherical base. The base is fitted in a socket that allows free movement of the stick. The movement of the stick controls the cursor or pointer on the screen. In a joystick, the cursor keeps moving in the direction of the joystick unless it is upright, whereas in Mouse, the cursor moves only when the mouse moves.

5-Light pen

A light pen is a computer input device that looks like a pen. The tip of the light pen contains a light-sensitive detector that enables the user to point to or select objects on the display screen. Its light sensitive tip detects the object location and sends the corresponding signals to the CPU. It is not compatible with LCD screens, so it is not in use today. It also helps you draw on the screen if needed. The first light pen was invented around 1955 as a part of the Whirlwind project at the Massachusetts Institute of Technology (MIT).

6- Digitizer

It is a computer input device, it is also called a graphics tablet , it is a flat rectangular board used to input drawings or other graphical data. The user draws on the Digitizer with an electronic pen. The drawing movements are converted into digital signals that are sent to the computer as input and appear on the computer monitor or display screen.

7- Microphone

The microphone is a computer input device that is used to input the sound. It receives the sound and converts it into audio signals or sends it to a recording medium. The audio signals are converted into digital data and stored in the computer.

The microphone also enables the user to telecommunicate with others. It is also used to add sound to presentations and with webcams for video conferencing.

8- Magnetic Ink Character Recognition (MICR)

The MICR computer input device is designed to read the text printed with magnetic ink. MICR is a character recognition technology that makes use of special magnetized ink which is sensitive to magnetic fields. It is widely used in banks to process the cheques and other organizations where security is a major concern. It can process three hundred cheques in a minute with hundred-percent accuracy. The details on the bottom of the cheque (MICR No.) are written with magnetic ink. A laser printer with MICR toner can be used to print magnetic ink.

9- Touch Screen.

This input device allows users to interact or provide inputs to the device by using their finger. Today, most electronic devices come with touchscreen as an alternative to a mouse for navigating a graphical user interface. For example, by touching, you can unlock your phone, open emails, open files, play videos, etc.

It is also used in public places, such as shopping centers, hotels, and airports, where users may not have much experience working with computers. The user simply touches the screen for the desired menu item.

Output unit :

Output units are devices that allow computers to send data to other devices or to users. Output devices are used to display input data that has been processed by the computer into useful output information.

In general, the data that computers send to human users is in forms that we can understand. Most often, these forms include text, photographic, audio and video. The most widely known examples of output devices are:

1- Monitor (Screen):

- A monitor is an electronic output device that is also known as a video display terminal (VDT) or a video display unit (VDU).
- It is used to display images, text, video, and graphics information generated by a connected computer via a computer's video card. Although it is almost like a TV, its resolution is much higher than a TV.
- To display video in the monitor, the computer needs a video card (or graphics card) for converting the digital signal (i.e., data in the form of 0s and 1s) from the processor to an analog signal (i.e., data in the form of a continuous electrical wave) that the monitor can interpret.
- Monitors are described in two ways:
 - The first is by the number of colors that the screen can display. This can range from 4 to 65,536.
 - The second is by the quality, or resolution, of the screen, which is measured in picture elements (pixels). Pixels are tiny dots of light that combine to form images on the screen. Typical screens have 320 × 220 pixels, 640 × 480 pixels, or 1,024 × 768 pixels. The more pixels a screen has, the greater its resolution.
 - Both color and resolution are important for determining the performance and quality of a computer monitor.

There are many types of computer monitors :

Cathode Ray Tube (CRT) Monitors

It is a technology used in early monitors. It uses a beam of electrons to create an image on the screen. It comprises the guns that fire a beam of electrons inside the screen. The electron beams repeatedly hit the surface of the screen. These guns are responsible for generating RGB (Red, Green, Blue) colors, and more other colors can be generated with the help of combining these three colors.

Flat Panel Monitors

These types of monitors are lightweight and take less space. They consume less power as compared to CRT monitors. These monitors are more effective as they do not provide harmful radiation. These monitors are more expensive than CRTs. The flat-panel monitors are used in PDA, notebook computers, and cellular phones. These monitors are available in various sizes like 15", 17", 18" & 19" and more. The display of a flat-panel monitor is made with the help of two plates of glass. These plates contain a substance, which is activated in many ways. It has two types : **Liquid Crystal Display(LCD)** and **Gas Plasma Display**.

Touch Screen Monitors

These monitors are also known as an input device. It enables users to interact with the computer by using a finger or stylus instead of using a mouse or keyboard. When users touch the screen by their finger, an event occurs and forward it to the controller for processing. These types of screens include pictures or words that help users to interact with the computer. It takes input from the users by touching menus or icons presented on the screen.

LED Monitors

It is a flat screen computer monitor, which stands for light-emitting diode display. It is lightweight in terms of weight and has a short depth. As the source of light, it uses a panel of LEDs. Nowadays, a wide number of electronic devices, both large and small devices such as laptop screens, mobile phones, TVs, computer monitors, tablets, and more, use LED displays.

2- Printers

- In businesses, homes, and most settings where computers are found, users still produce hard copy (information in printed form). For most applications, soft copy (information in electronic form) is not sufficient.
- Printer - Used to print information on paper. Commonly uses either lasers or inkjets to place ink onto the page to create text and high-quality images.
- There are many types of cables used to connect the printer with the computer : USB, parallel, serial, and wireless connection in some modern printers.
- There are many types of printers, The most commonly used computer printers are:

- **Dot-matrix printer**, which can still be found in service today. These inexpensive printers are appropriate for tasks that do not require high-quality images. As its name implies, the dot-matrix printer produces a series of dots in a matrix to form both characters and images. A print head containing 9, 18, or 24 tiny pins strikes an inked ribbon to create the dots that make up the image on paper. The number of pins determines the quality of the output; the greater the number, the smoother the output.
- **Laser printer:** Low cost and very high image quality, The laser printer can produce both characters of any size and high-quality graphic images. A laser beam draws the desired image on the printer's metal drum. The drum attracts toner (powdered ink) where light strikes it, and the image is transferred from the drum to the paper using heat.
- **Inkjet printer:** In the inkjet printing mechanism, the print head has several tiny nozzles, also called jets. As the paper moves past the print head, the nozzles spray the ink onto it, forming the characters and images. An inkjet printer can produce from 100 to several hundred pages, depending on the nature of the hard copy, before the ink cartridges must be replaced.
- **Plotters Printer:** Plotters printers are very different from other printers. Unlike other printers, Pen Plotters print by moving a pen across the surface of a piece of paper. Plotters printer is the best way to produce color high-resolution vector-based artwork, or very large drawings efficiently.

3- Speakers and headsets are the two most common devices used for audio output. Converts digital signals into audible sound waves. It connects to the sound card.

4- Projectors are used to display graphics, text, video output from a computer. In the case of projectors, the output is displayed onto a screen for an audience to view instead of into a monitor for a single user's viewing. projectors are attached to the computer through different cables . Projector technology varies widely, but the two most common types are LCDs projectors and digital light processing (DLP) projectors.

STORAGE SYSTEM

- Memory devices are any devices that are capable of storing information temporarily or permanently.
- There are two types of memory; primary and secondary.
- Primary storage devices: primary storage is also referred to as internal memory. This is a component that is present inside the CPU which is used to store the temporary files and process them to get immediate results. The information in primary memory is usually volatile, which is used to store instructions and data temporarily; it disappears when the computer's power is turned off. Primary memory refers to RAM (random access memory).
- Secondary storage devices: Which is external to the computer system. It is not as primary storage as the information saved in storage media is nonvolatile and remains in the computer even when power is off.
- The primary memory is called memory, and the secondary memory is called storage.
- In general, data and instructions are kept in secondary storage when not needed for processing. When required for processing by the CPU, they are retrieved from storage, sent to memory, where kept until processed.
- Storage and memory are usually measured in bytes, which consist of 8 bits (binary digits of 0 or 1). A single byte is used to encode a single character (letter or number).

Memory Measurement Units

- 0 or 1= 1 bit.
- 8 bit=1 byte.
- 1024 bytes=1 kilobyte (KB).
- 1024 KB=1 megabyte (MB)
- 1024 MB=1 gigabyte (GB)
- 1024 GB=1 terabyte (TB).
- 1024 TB= 1 petabyte(PB)

Examples of Storage devices in a computer:

1- Primary storage devices

RAM

RAM means random access memory which is used to access any temporary data and to get intermediate results for the usage of that information. It is also known as temporary memory because the data will be stored only till the computer system is on, if it's turned off the data will be lost.

ROM

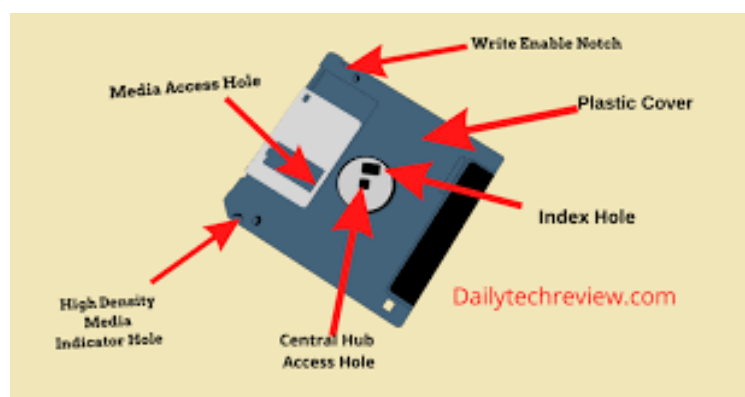
ROM means read-only memory. This is also known as non-volatile memory as the information here is stored permanently until and unless it's deleted by the user.

2- Secondary storage devices :

Magnetic storage devices:

Floppy disk

It is a type of storage device which is used in the personal computer. It employs magnetic storage technology. Floppy disk is generally used with plastic and is made secure by using protective cases. A single floppy can store 1.44 MB.



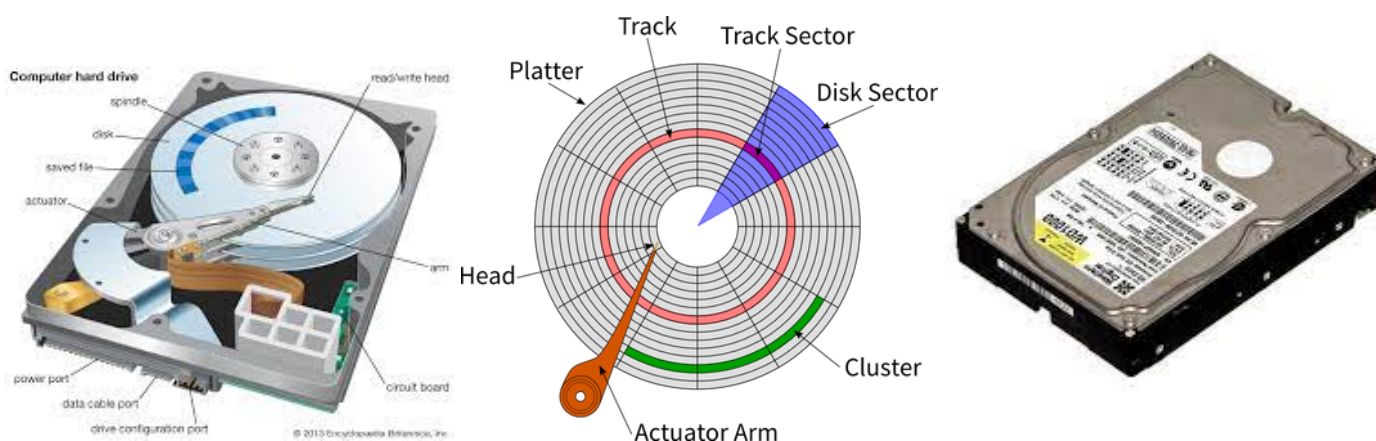
Hard disk

It's a hard disc drive (HDD) that uses magnetic storage to store and retrieve data. It's a non-volatile device that stores data that could be changed or deleted an infinite number of times. Hard drives have a faster data access time than floppy disks.

Data access time is the time required to locate a piece of stored information in storage and retrieve it into primary memory or the CPU. Current PC hard disks typically have a capacity reach to 4 TB or more .

A magnetic hard disk is organized or formatted into tracks and sectors. Each track is divided into a number of sectors, and each track and sector has a physical address that is used by the operating system to locate particular data records.

Hard disks typically have from a few hundred to thousands of tracks. There are a constant number of tracks/sectors, with outer sectors using more surface area than the inner sectors. The arrangement of tracks and sectors on a disk is known as the format, shown below.



Optical storage devices

CD : is optical storage media that employ laser technology that can store up to 680MB. CDs are often read-only, many PCs are now equipped with CD drives that allow the user to record information on the CD by burning tiny holes into disk surfaces with laser beams, and it can read data by laser beam also. Some writable CDs can be recorded on only once. These are designated as CD-R (compact disc-recordable). Other CDs can be recorded multiple times and are designated as CD-RW (compact disc-rewritable).

DVD: Digital Versatile Disc. It is available in two distinct sizes: 4.7Gigabyte solitary discs and 8.5Gigabyte dual discs. Video data (e.g., movies) can be stored on DVDs . As with CDs, there is a DVDs (DVD-R) that allows the user to record video data from his or her computer, provided that the computer is equipped with a DVD writer.

Flash memory devices

Pen drive

This is also called a USB drive since it has flash memory and a built-in USB interface. These devices can be immediately connected to our desktops and laptops, allowing us to read data into them even more quickly and efficiently.

SSD

SSDs store data permanently inside an integrated circuit, typically using flash memory. The flash memory inside an SSD means data is written, transferred, and erased electronically and silently — SSDs don't have the moving parts found inside mechanical hard-disk drives (HDDs). Without moving parts, SSDs are fast and quiet, but they have a high price tag compared to HDDs.

Sd card

A Contactless Smart Card is what it's called. It is commonly used for storing greater information on electronic devices such as phones, cameras, and so on.

Memory card

It's commonly found in digital cameras, printers, gaming consoles, and other electronic devices. It may be used to carry lots of data and comes in a variety of sizes. A memory card reader is required to use a storage device on a computer.

Cloud and virtual storage

Digital or cloud storage systems have replaced secondary memory in recent years. We can keep our documents and other items on the cloud for just as much as we subscribe to cloud storage. Many corporations, namely amazon, google, Microsoft, and others, offer cloud services.

Processing Unit

- Processing is the core function of any computer. When a computer receives data from an input device, this data must first go through an intermediate stage before it is sent to an output device.
- Processing is the intermediate stage where raw data is transformed into information so that it can be meaningful output for the user.
- An example of a processing device is the central processing unit (CPU), which is a set of electronic circuitry that processes and executes instructions.
- The CPU is the brain of any computer system. It controls the functioning of the other units and process the data.
- The CPU is sometimes called the processor, or in the personal computer field called “microprocessor”. It is a single integrated circuit that contains all the electronics needed to execute a program.

- The CPU consists of:

1- ALU(Arithmetic and Logic unit)

ALU can also be subdivided into two sections namely, arithmetic unit and logic unit. It is a complex digital circuit which consists of registers and which performs arithmetic and logical operations. Arithmetic sections perform arithmetic operations like addition, subtraction, multiplication, division etc. All other Complex operations can also be performed by repetition of these above basic operations. The logic unit is responsible for performing logical operations such as comparing, selecting, matching and merging of different data or information.

2- Control Unit

It is the unit which controls all the operations of the different units but does not carry out any actual data processing operation. Control unit transfers data or instruction among different units of a computer system. It receives the instructions from the memory, interprets them and sends the operation to various units as instructed.

Control unit is also responsible for communicating with all input and output devices for transferring or receiving the instruction from the storage

units. So, the control unit is the main coordinator since it sends signals and finds the sequence of instructions to be executed.

3- Register set

- A processor register (CPU register) is one of a small set of data holding places that are part of the computer processor. Each register performs a specific function.
- A register may hold an instruction, a storage address, or any kind of data (such as a bit sequence or individual characters).
- There are many different types of registers:
 - **Memory Address Register (MAR):** This register holds the address of memory where the CPU wants to read or write data.
 - **Memory Buffer Register (MBR):** This register holds the contents of data or instruction read from, or written in memory.
 - **I/O Address Register (I/O AR):** I/O Address register is used to specify the address of a particular I/O device.
 - **Program Counter (PC):** register is also known as Instruction Pointer Register. This register is used to store the address of the next instruction to be fetched for execution. When the instruction is fetched, the value of IP is incremented.
 - **Instruction Register (IR):** Once an instruction is fetched from main memory, it is stored in the Instruction Register. The control unit takes instruction from this register, decodes and executes it by sending signals to the appropriate component of the computer to carry out the task.

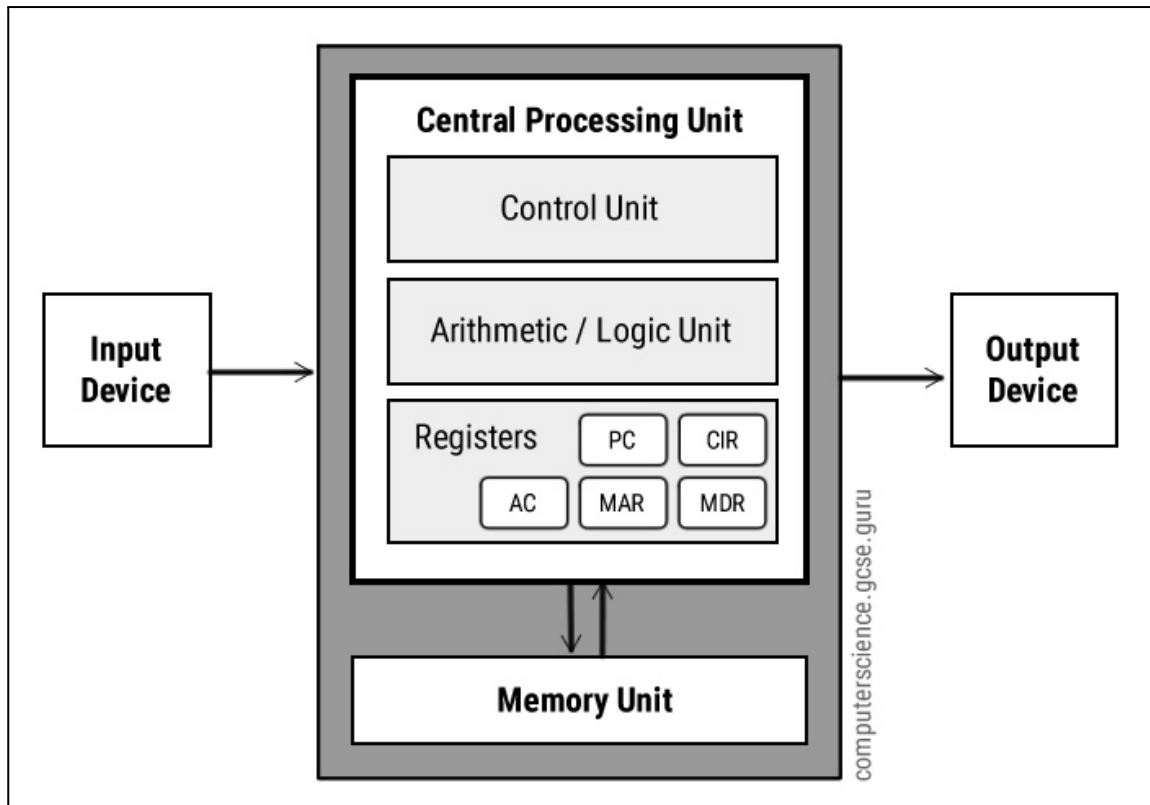


Figure 1: CPU components

Machine cycle:

- The transformation of data into information is called the Processing or Machine cycle.
- **The Machine cycle consists of two sub-cycles:**
 - a. The Instruction cycle : In this cycle, the control unit do the following:
 1. Fetch an instruction from the memory
 2. Decode the instruction (i.e., determine the instruction type),
 - b. The Execution cycle: in this cycle , the ALU (3)executes the instructions by performing an arithmetic, comparison, or logical operation on the data in the registers.

The instructions

- Basic computer instructions are the elementary operations that a computer system can perform. These instructions are typically divided into three categories: data movement instructions, arithmetic and logic instructions, and control instructions.
- Data movement instructions are used to move data between different parts of the computer system. These instructions include load and store instructions, which move data between memory and the CPU, and input/output (I/O) instructions, which move data between the CPU and external devices.
- Arithmetic and logic instructions are used to perform mathematical operations and logical operations on data stored in the system. These instructions include add, subtract, multiply, and divide instructions, as well as logic instructions such as AND, OR, and NOT.
- Control instructions are used to control the flow of instructions within the computer system. These instructions include branch instructions, which transfer control to different parts of the program based on specified conditions, and jump instructions, which transfer control to a specified memory location.

1- System clock

- A system clock or timer uses a quartz crystal oscillator to generate pulses.
- These pulses are counted as the number of cycles per second. Then the cycles are counted into Hertz.
- One megahertz equals one million cycles per second.) A modern computer has a million (MHz) or billion hertz per second (GHz). A 3.2GHz processor means it has 3.2 billion cycles per second.
- The clock cycle helps in determining the speed of the CPU, as it is considered the basic unit of measuring how fast an instruction can be executed by the computer processor.

System	
Processor:	Intel(R) Core(TM) i5-3320M CPU @ 2.60GHz 2.60 GHz
Installed memory (RAM):	4.00 GB (3.87 GB usable)
System type:	64-bit Operating System, x64-based processor
Pen and Touch:	No Pen or Touch Input is available for this Display

2- BUSES

Is a computer link used in a computer system to send data, memory addresses, control signals, and power supplies to various hardware components in a computer system.

There are two types of computer buses : The system bus connects the CPU to primary memory, allowing instructions and data to be exchanged. Expansion buses connect the CPU to peripheral devices, allowing data to travel from the CPU to the expansion ports and out through the expansion cards to the peripheral devices attached to the computer.

Types of System Buses

If you look at the bottom of a motherboard you'll see a whole network of lines or electronic pathways that join the different components together. This network of wires or electronic pathways is called the 'Bus'. There are three types of system buses:

I-Data Bus

Data Bus can be considered as a highway on which data travels within a computer. This bus connects all the computer components to the CPU and main memory. The size (width) of the bus determines how much data can be transmitted at one time. A 16-bit bus can transmit 16 bits of data at a time or a 32-bit bus can transmit 32 bits at a time.

II-Address Bus

A collection of wires carries information about the location of data in memory in order to either read data from, or write data to, that memory location.

In other words, the information used to describe the memory locations traveled along the address bus.

The size of the address bus determines how many memory locations can be addressed.

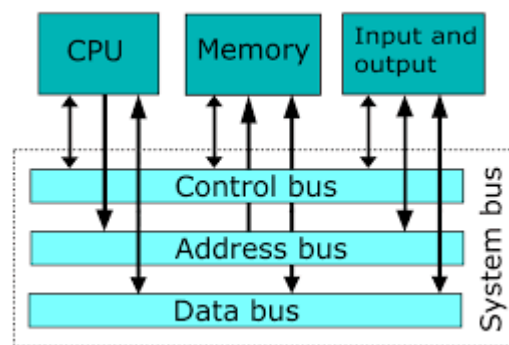
A system with a 4-bit address bus can address $2^4 = 16$ Bytes of memory. A system with a 16-bit address bus can address $2^{16} = 64$ KB of memory. A system with a 20-bit address bus can address $2^{20} = 1$ MB of memory.

III-Control Bus

- The connections that carry control information between the CPU and other devices within the computer are called Control Buses.
- The control bus carries signals that report the status of various devices. This bus is used to indicate whether the CPU is reading from memory or writing to memory.

Functions of computer buses

1. **Data sharing** – All types of buses used in the network transfer data between the connected computer peripherals. The buses either transfer or send data in serial or parallel transfer methods. Buses are classified according to how many bits they can move simultaneously, meaning we have 8-bit, 16-bit, 32-bit, or even 64-bit buses.
2. **Addressing** – A bus has address lines that suit the processors. This allows us to transfer data to or from different locations in the memory.
3. **Power** – A bus supplies the power to various connected peripherals.



3-BUFFERS:

- Peripheral devices are very slow compared to the speed of the CPU. To keep the computer running efficiently, data traveling to and from peripheral devices are placed in a buffer.
- A buffer is a storage area where data resides before being processed.
- Microcomputers have buffers in RAM and in peripheral devices such as printers. The CPU coordinates data being transferred to and from peripheral devices by using buffers. When the buffer is empty, the CPU is interrupted and a special request is made to fill the buffer with more data.

ASCII

- When data or programs are sent between the computer and its peripheral equipment, a fixed length, binary-based code is commonly used.
- Fixed length code allows communicating devices to tell where one character ends and another begins. Such codes represent digits, alphabetic, and special characters such as \$ sign and # sign.
- The well-known codes are ASCII (American Standard Code for Information Interchange).
- ASCII originally was designed as a 7-bits to represent ($2^7=128$ characters), ASCII also developed to 8-bits version because computers are designed to handle data with 8-bits. The 8 bits that represent a character in ASCII are collectively referred to as a byte.
- Conversion from natural language words and numbers to ASCII equivalents and back again usually takes place within the input and output device. When a user types a message, an encoder chip inside the keyboard translates this input to ASCII and sends it as a series of bytes to the CPU, the output that the CPU sends to the display screen is also coded in ASCII, the decoder chip translates this code into understandable words and numbers, if the CPU were to send the ASCII message 0100100001001001 to display device the word HI would appear on screen.

LETTER	ASCII VALUES	BINARY VALUES	LETTER	ASCII VALUES	BINARY VALUES
A	65	01000001	A	97	01100001
C	67	01000011	C	99	01100011
D	68	01000100	D	100	01100100
E	69	01000101	E	101	01100101
F	70	01000110	F	102	01100110
G	71	01000111	G	103	01100111
H	72	01001000	H	104	01101000
I	73	01001001	I	105	01101001
J	74	01001010	J	106	01101010
K	75	01001011	K	107	01101011
L	76	01001100	L	108	01101100
M	77	01001101	M	109	01101101
N	78	01001110	N	110	01101110
O	79	01001111	O	111	01101111
P	80	01010000	P	112	01110000
Q	81	01010001	Q	113	01110001
R	82	01010010	R	114	01110010
S	83	01010011	S	115	01110011
T	84	01010100	T	116	01110100
U	85	01010101	U	117	01110101
V	86	01010110	V	118	01110110
W	87	01010111	W	119	01110111
X	88	01011000	X	120	01111000
Y	89	01011001	Y	121	01111001
Z	90	01011010	Z	122	01111010

The parity bit

Suppose you press the B key on your computer's keyboard, it will transmit the byte 01000010 to the CPU. Sometimes, something happens during transmission, for example the 6th bit changes from 0 to 1. Unless something indicates the mistake to the CPU, it will wrongly interpret the byte as the letter F.

To enable the CPU to detect such error, an additional bit position is added to ASCII byte called parity bit is automatically set to either 0 or 1 to force the sum of the 1 bits in a byte to either an even or an odd number.

Computer systems support either even or odd parity. In an odd parity system, the parity bit forces the 1 bits in a byte to add up to an odd number. In even parity system make them add up to even number see the following table illustrate the word "HELLO" with even-parity system:

The parity bit is automatically generated by the keyboard's own circuitry. If you were to type the B character on an even parity system, the keyboard would send 010000100 up the line to the CPU. If the message then became an error occur 010001100 the CPU immediately sense the error.

Even Parity

