# Introduction to Computers

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## References
1.0 INTRODUCTION TO COMPUTER SYSTEMS

1.1. DEFINITION/TERMINOLOGIES

(a) Digital Computer
A computer is a Programmable digital electronic device that can store, retrieve, process data and display the processed data (information)
Or
A computer is a device which works under the control of stored instructions (programs), automatically accepting and processing data to produce information (that is the result of that processing).
Or
A computer is an electronic device, operating under the control of instructions stored in its own memory that can accept data (input), manipulate the data according to specified rules (processes), produce results (output), and store the results for future use.

(b) Data
Data is input from user or other sources. It may be numbers, text, sound, images, etc. may be unintelligible (i.e. unrecognizable), may be commands or instructions
Or
Data is a collection of un-organized facts, which can include words, numbers. Images, and sounds. Computers manipulate and process data to create information.

(c) Information
Information is the output from the computer. It is formatted and understandable, can be printed text, graphics, images, sounds or video.
Or
Information is data that is organized, has meaning, and is useful. Examples are reports, newsletters, a receipt, a picture, an invoice, or a check. Data is processed and manipulated to create a check.
Data entered into a computer is called input. The processed results are called output.
Thus, a computer processes input to create output. A computer also can hold data and information for future use in an area called storage. This cycle of input, process, output, and storage is called the information processing cycle.
(d) **Hardware**

Hardware is the physical (the electric, electronic, and mechanical) components of the computer. These include processor, motherboard, memory, drives, video/sound cards etc.

(e) **Instruction**

*Instruction* is a command in binary that is recognized and executed by the computer to accomplish task.

(f) **Program**

*A program* is the set of instructions written for the computer to perform a task. A group of programs is called *software*.

(g) **Software**

*Software* is the series of instruction that tells the hardware how to perform tasks. Without software, hardware is useless; hardware needs the instructions provided by software to process data into information.

(h) **Firmware**

*Firmware* are programs (set of instructions) that sit on a microchip in hardware (i.e. are programs stored in hardware e.g. in ROM). They are often used to start up (i.e. boot) the machine. It keeps settings such as "bios" (i.e., configuration) system settings.

(i) **Liveware**

A person that communicates with a computer or uses the information it generates is called a user (live ware).

(j) **Peripherals:**

Computer peripherals are the term used to describe all the elements connected to the computer apart from the computer itself. These are the facilities/equipments connected to the computer to assist the computers in satisfying its users.
1.2  **DIGITAL VS ANALOGUE**

1.2.1  **Numerical Presentation**

In science, technology, business, and, in fact, most other fields of endeavour, we are constantly dealing with quantities. Quantities are measured, monitored, recorded, manipulated arithmetically, observed, or in some other way utilized in most physical systems. It is important when dealing with various quantities that we be able to represent their values efficiently and accurately. There are basically two ways of representing the numerical value of quantities: analog and digital.

1.2.2  **Analog Representation**

In analog representation a quantity is represented by a voltage, current, or meter movement that is proportional to the value of that quantity. Analog quantities such as those cited above have an important characteristic: they can vary over a continuous range of values.

The following is a diagram of *analog voltage vs time*:

![Analog Voltage vs Time](image)

Figure 1.1. analogue waveform

1.2.3  **Digital Representation**

In digital representation the quantities are represented not by proportional quantities but by symbols called digits. As an example, consider the digital watch, which provides the time of day in the form of decimal digits which represent hours and minutes (and
sometimes seconds). As we know, the time of day changes continuously, but the digital watch reading does not change continuously; rather, it changes in steps of one per minute (or per second). In other words, this digital representation of the time of day changes in discrete steps, as compared with the representation of time provided by an analog watch, where the dial reading changes continuously.

Digital quantities are represented using digits.

The following is a diagram of digital voltage vs time:

![Digital Voltage vs Time](image)

The major difference between analog and digital quantities, then, can be simply stated as follows:

**Analog** = changes continuously

**Digital** = changes in discrete steps (step by step)

### 1.2.4 Advantages and Limitations of Digital Techniques

*(i) Advantages*

- Easier to design. Exact values of voltage or current are not important, only the range (HIGH or LOW) in which they fall.
- Information storage is easy.
- Accuracy and precision are greater.
- Operation can be programmed. Analog systems can also be programmed, but the variety and complexity of the available operations is severely limited.
✧ Digital circuits are less affected by noise. As long as the noise is not large enough to prevent us from distinguishing a HIGH from a LOW.
✧ More digital circuitry can be fabricated on IC chips.

(ii) Limitations

There is really only one major drawback when using digital techniques:
✧ The real world is mainly analog.

Most physical quantities are analog in nature, and it is these quantities that are often the inputs and outputs that are being monitored, operated on, and controlled by a system. To take advantage of digital techniques when dealing with analog inputs and outputs, three steps must be followed:
1. Convert the real-world analog inputs to digital form. (ADC)
2. Process (operate on) the digital information.
3. Convert the digital outputs back to real-world analog form. (DAC)

The following diagram shows a temperature control system that requires analog/digital conversions in order to allow the use of digital processing techniques.

Figure 1.3. Signal conversion
1.3 **DIGITAL NUMBER SYSTEM**

Many number systems are in use in digital technology. The most common are the decimal, binary, octal, and hexadecimal systems. The decimal system is clearly the most familiar to us because it is a tool that we use every day. Examining some of its characteristics will help us to better understand the other systems.

### 1.3.1 Decimal System

**Decimal System** The decimal system is composed of 10 numerals or symbols. These 10 symbols are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9; using these symbols as digits of a number, we can express any quantity. The decimal system, also called the base-10 system because it has 10 digits.

<table>
<thead>
<tr>
<th>10^3</th>
<th>10^2</th>
<th>10^1</th>
<th>10^0</th>
<th>10^-1</th>
<th>10^-2</th>
<th>10^-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>=1000</td>
<td>=100</td>
<td>=10</td>
<td>=1</td>
<td>.</td>
<td>=0.1</td>
<td>=0.01</td>
</tr>
</tbody>
</table>

Most Significant Digit

Decimal point

Least Significant Digit

### 1.3.2 Binary System

In the binary system, there are only two symbols or possible digit values, 0 and 1. This base-2 system can be used to represent any quantity that can be represented in decimal or other number system.

<table>
<thead>
<tr>
<th>2^3</th>
<th>2^2</th>
<th>2^1</th>
<th>2^0</th>
<th>2^-1</th>
<th>2^-2</th>
<th>2^-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>=8</td>
<td>=4</td>
<td>=2</td>
<td>=1</td>
<td>.</td>
<td>=1/2</td>
<td>=1/4</td>
</tr>
</tbody>
</table>

Most Significant Bit

Binary point

Least Significant Bit
1.3.3 Binary Counting

The Binary counting sequence is shown in the table:

<table>
<thead>
<tr>
<th>$2^3=8$</th>
<th>$2^2=4$</th>
<th>$2^1=2$</th>
<th>$2^0=1$</th>
<th>Decimal Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>

1.3.4 Representing Binary Quantities

In digital systems the information that is being processed is usually presented in binary form. Binary quantities can be represented by any device that has only two operating states or possible conditions. E.g. a switch has only open or closed. We arbitrarily (as we define them) let an open switch represent binary 0 and a closed switch represent binary 1. Thus we can represent any binary number by using series of switches.

Typical Voltage Assignment

Binary 1: Any voltage between 2.4V to 5V
Binary 0: Any voltage between 0V to 0.8V
Not used: Voltage between 0.8V to 2V, this may cause error in a digital circuit
We can see another significant difference between digital and analog systems. In digital systems, the exact value of a voltage is not important; e.g., a voltage of 3.6V means the same as a voltage of 4.3V. In analog systems, the exact value of a voltage is important.

(a) Binary-To-Decimal Conversion
Any binary number can be converted to its decimal equivalent simply by summing together the weights of the various positions in the binary number which contain a 1.

\[
\begin{array}{c|c}
\text{Binary} & \text{Decimal} \\
\hline
1 1 0 1 1 2 & (binary) \\
2^4+2^3+0+2^1+2^0 & = 16+8+0+2+1 \\
& = 27_{10} \text{ (decimal)} \\
\end{array}
\]

And

\[
\begin{array}{c|c}
\text{Binary} & \text{Decimal} \\
\hline
1 0 1 1 0 1 0 1 2 & (binary) \\
2^7+0+2^6+2^4+0+2^2+0+2^0 & = 128+0+32+16+0+4+0+1 \\
& = 181_{10} \text{ (decimal)} \\
\end{array}
\]

You should noticed the method is find the weights (i.e., powers of 2) for each bit position that contains a 1, and then to add them up.

(b) Decimal-To-Binary Conversion
There are 2 methods:

(i) Reverse of Binary-To-Digital Method

\[
\begin{array}{c|c}
\text{Decimal} & \text{Binary} \\
\hline
45_{10} & = 32 + 0 + 8 + 4 + 0 + 1 \\
& = 2^5+0+2^3+2^2+0+2^0 \\
& = 1 0 1 1 0 1 2 \\
\end{array}
\]
**(ii) Repeat Division**

This method uses repeated division by 2. Eg. convert 25₁₀ to binary

<table>
<thead>
<tr>
<th>Division</th>
<th>Quotient</th>
<th>Remainder</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>25/ 2</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12/ 2</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 / 2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 / 2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1 / 2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Result: \(25_{10} = 11001_2\)

The Flow chart for repeated-division method is as follow:

![Flow chart](image)
1.4 OCTAL NUMBER SYSTEM

The octal number system has a base of eight, meaning that it has eight possible digits: 0, 1, 2, 3, 4, 5, 6, 7.

\[
\begin{array}{|c|c|c|c|c|c|c|c|}
\hline
8^3 & 8^2 & 8^1 & 8^0 & 8^{-1} & 8^{-2} & 8^{-3} \\
\hline
=512 & =64 & =8 & =1 & \cdot & =1/8 & =1/64 & =1/512 \\
\hline
\end{array}
\]

Most Significant Digit | Octal point | Least Significant Digit
--- | --- | ---
(a) Octal to Decimal Conversion
e.g. \(24.6_8 = 2 \times (8^1) + 4 \times (8^0) + 6 \times (8^{-1}) = 20.75_{10}\)

(b) Binary-To-Octal / Octal-To-Binary Conversion

<table>
<thead>
<tr>
<th>Octal Digit</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary Equivalent</td>
<td>000</td>
<td>001</td>
<td>010</td>
<td>011</td>
<td>100</td>
<td>101</td>
<td>110</td>
<td>111</td>
</tr>
</tbody>
</table>

Each Octal digit is represented by three bits of binary digit.
e.g. \(100\ 111\ 010_2 = (100) (111) (010)_2 = 4\ 7\ 2_8\)

(c) Repeating Division

This method uses repeated division by 8. E.g. convert \(177_{10}\) to octal and binary:

<table>
<thead>
<tr>
<th>(177/8)</th>
<th>= 22 + remainder of 1</th>
<th>(1) (Least Significant Bit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(22/8)</td>
<td>= 2 + remainder of 6</td>
<td>6</td>
</tr>
<tr>
<td>(2/8)</td>
<td>= 0 + remainder of 2</td>
<td>(2) (Most Significant Bit)</td>
</tr>
<tr>
<td>Result</td>
<td>(177_{10} = 261_8)</td>
<td>Convert to Binary = 010110001_2</td>
</tr>
</tbody>
</table>
### 1.5 HEXADECIMAL NUMBER SYSTEM

The hexadecimal system uses base 16. Thus, it has 16 possible digit symbols. It uses the digits 0 through 9 plus the letters A, B, C, D, E, and F as the 16 digit symbols.

<table>
<thead>
<tr>
<th>$16^3$</th>
<th>$16^2$</th>
<th>$16^1$</th>
<th>$16^0$</th>
<th>$16^{-1}$</th>
<th>$16^{-2}$</th>
<th>$16^{-3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>=4096</td>
<td>=256</td>
<td>=16</td>
<td>=1</td>
<td>=1/16</td>
<td>=1/256</td>
<td>=1/4096</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Most Significant Digit</th>
<th>Hexadec. point</th>
<th>Least Significant Digit</th>
</tr>
</thead>
</table>

(a) **Hexadecimal to Decimal Conversion**

E.g. $2AF_{16} = 2 \times (16^2) + 10 \times (16^1) + 15 \times (16^0) = 687_{10}$

Repeat Division: Convert decimal to hexadecimal

This method uses repeated division by 16. Eg. convert 37810 to hexadecimal and binary

| 378/16 | = 23+ remainder of 10 | A (Least Significant Bit) |
| 23/ 16 | = 1 + remainder of 7 | 7 |
| 1 / 16 | = 0 + remainder of 1 | 1 (Most Significant Bit) |
| Result | 37810 = | 17A8 |
| Convert to Binary | = 0001 0111 10102 |
| | = 0000 0001 0111 1010 (16 bits) |

(b) **Binary-To-Hexadecimal / Hexadecimal-To-Binary Conversion**

<table>
<thead>
<tr>
<th>Hexadecimal Digit</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary Equivalent</td>
<td>0000</td>
<td>0001</td>
<td>0010</td>
<td>0011</td>
<td>0100</td>
<td>0101</td>
<td>0110</td>
<td>0111</td>
</tr>
<tr>
<td>Hexadecimal Digit</td>
<td>8</td>
<td>9</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>Binary Equivalent</td>
<td>1000</td>
<td>1001</td>
<td>1010</td>
<td>1011</td>
<td>1100</td>
<td>1101</td>
<td>1110</td>
<td>1111</td>
</tr>
</tbody>
</table>

Each Hexadecimal digit is represented by **four** bits of binary digit.

E.g. $1011 \ 0010 \ 1111_2 = (1011) \ (0010) \ (1111)_2 = B \ 2 \ F_{16}$

(c) **Octal-To-Hexadecimal / Hexadecimal-To-Octal Conversion**

(1) Convert Octal (Hexadecimal) to Binary first.
(2a) Regroup the binary number in 3 bits a group starts from the LSB if Octal is required.

(2b) Regroup the binary number in 4 bits a group from the LSB if Hexadecimal is required.

eg. Convert 5A816 to Octal.

<table>
<thead>
<tr>
<th>5A816</th>
<th>= 0101 1010 1000 (Binary)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= 2 6 5 0 (Octal)</td>
</tr>
</tbody>
</table>

### 1.6 BYTE PREFIXES

When one start talking about lots of bytes, the person get into prefixes like kilo, mega and giga, as in kilobyte, megabyte and gigabyte (also shortened to K, M and G, as in Kbytes, Mbytes and Gbytes or KB, MB and GB). In bits they becomes Kbits (Kb), Mega Bits (Mb) etc The following table shows the binary multipliers:

- *Bit* is short form for binary digit (a 0 or a 1).
- *Nibble* is a group of 4 bits.
- *Byte* is a group of 8 bits. Kilobit is 1024 (2^10) bits.

<table>
<thead>
<tr>
<th>Name</th>
<th>Abbr.</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilo</td>
<td>K</td>
<td>2^10 = 1,024</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>2^20 = 1,048,576</td>
</tr>
<tr>
<td>Giga</td>
<td>G</td>
<td>2^30 = 1,073,741,824</td>
</tr>
<tr>
<td>Tera</td>
<td>T</td>
<td>2^40 = 1,099,511,627,776</td>
</tr>
<tr>
<td>Peta</td>
<td>P</td>
<td>2^50 = 1,125,899,906,842,624</td>
</tr>
<tr>
<td>Exa</td>
<td>E</td>
<td>2^60 = 1,152,921,504,606,846,976</td>
</tr>
<tr>
<td>Zetta</td>
<td>Z</td>
<td>2^70 = 1,180,591,620,717,411,303,424</td>
</tr>
<tr>
<td>Yotta</td>
<td>Y</td>
<td>2^80 = 1,208,925,819,614,629,174,706,176</td>
</tr>
</tbody>
</table>
From the chart, that kilo is about a thousand, Mega is about a million, Giga is about a billion, and so on. So when someone says, "This computer has a 2 Giga hard drive," what he or she means is that the hard drive stores 2 Gigabytes, or approximately 2 billion bytes, or exactly 2,147,483,648 bytes. Terabyte databases are fairly common these days, and there are petabyte in the server storage platform.

HP 3PAR StoreServ Storage has a capacity of 3.2 PB
2.0 ELEMENTS OF A COMPUTER SYSTEM

All computer parts are categorized as one of the following:

✧ Central Processing Unit - performs computation (arithmetic and logical operations and decision making).

✧ Input device - Enables the microprocessor to receive input information (data and information).

✧ Output device- used to display the results processed by the microprocessor.

✧ Memory (main and auxiliary storage) - used to store data, information and instructions.

✧ The bus system- these are used to interconnect various input, output and memories to the microprocessor.

✧ Input/Output Port – interfaces the computer system with the outside world

Practically, the input and output elements does not connect directly to the CPU. They do so through an Input/Output interface. These are sometimes referred to as input/output ports. They control the flow of data/information between the CPU and the outside world.
2.1 HISTORY OF COMPUTERS

Throughout time, humans have invented ingenious calculating machines. One of the earliest was the abacus. It's about 5,000 years old. Mechanical calculators that could add and multiply (but not subtract!) were invented in the 1600s. In 1820, Charles Xavier Thomas de Colman invented the arithometer, a machine that could add, subtract, multiply and divide. It was Charles Babbage though, in the early 1800s, who designed mechanical calculating machines (see photo) that were the true ancestor of today's computers. Ada Byron King (Countess of Lovelace) was his programmer and today is considered the mother of computer programming.

Babbage's design for his ultimate calculator, the Analytical Engine, was never produced. It did anticipate the four components essential to modern computing. These components are input, storage, processing and output.

The problem with Babbage's and other mechanical calculators was just that—they were mechanical. The moving parts they relied on were slow and subject to breakdown. What made modern computers possible was the invention of something that could do calculations and other information processing with no moving parts and do it very fast. That something was electronic components. With electronic components, a fast and efficient machine such as Babbage proposed could be built with all four components essential to modern computing.
2.2 COMPUTER GENERATIONS

This gives a grouped summary of the gradual developments in the computer technology. The computers of like technological characteristics are grouped into a “generation”.

The various generations are:

2.2.1 First Generation Computers.

These were valve based machines.

They were the earliest time computers, which were in use from around the mid-1950’s to late 1950’s. Their circuit incorporated thermonic valves (vacuum tubes) as major elements (non-solid electronics device). These computers were big in their physical size, expensive to operate, consumed a lot of power, generated a lot of heat, and hence non-reliable as the circuitry components were prone to failure. They had limited internal memory (based on magnetic drums) and were generally very slow. They relied on machine language (string of ones and zeros) to perform operations and could only solve one problem at a time. Input was based on punched cards and paper tape, and output was displayed on printouts.

![vacuum tubes](image)

Their design was based on the John Von Neumanns's criterion. Examples include the UNIVAC and ENIAC mainframe computers.
Figure 2.4. UNIVAC and ENIAC
2.2.2 Second Generation computers.

These were transistor based. The transistor was invented in 1947 but was not widely used until late 50’s. The second generation computers were computers of the closing of the 1950’s to early 1960’s which used transistors, which are relatively smaller, cheaper and faster, to replace the valves. The transistors consumed comparatively less power and therefore the resulting computers were more reliable and comparatively small in size. The transistor and the diodes were based on the solid state technology that is the electrical pulses were not to flow through a vacuum as the case of the thermionic valves of the first generation computers.

Their internal storage was higher than those of the first generation computers. The core memories were used as internal memory for storage of instructions. The speed was higher and the system were more reliable. These used assembly and high level programming languages (vocabularies are close to the human's natural language, English language.). Second generation machines were basically mainframe computers. Examples of the Second Generation Computers include IBM 300 Series, ATLAS.
2.2.3 Third Generation Computers.

The computers of this generation came into being towards mid 1960’s up to around mid 1970’s and they used integrated circuits to replace the second generation physical transistors, diodes, etc. The integrated circuits combine several physical electronic components within a small crystal called the silicon chip.

The ICs (Integrated Circuits) are much smaller as compared to the physical electronic components hence the resulting computers were reduced in size as compared to the second generation computers. The small circuitry that resulted, improved the processing speed for pulses, e.g., data pulses can flow faster from one module to another as compared to the flow within the larger circuits, where they travel considerable distance.

Figure 2.7 ICs (Integrated Circuits)

Hence they had improved processing speed, higher internal memory capacity and were more reliable. The use of magnetic disks for secondary storage became widespread. Users interacted with the machines through Keyboards and monitor and interfaced with an operating system, which allowed the device; to run many different applications at one time (multiprogramming and timesharing), with a central program that monitored the memory. Computers became accessible to the mass audience because of reduction in cost and size. These computers could support more than one user at the same time, as connected through communication links from the work stations, which can be situated over a long distance or within the same locality of the host computer, that is to say in short that these computers have got the capability to support communication facilities, i.e., remote communication facilities. Examples of such computers are ICL 1900 Series, IBM 360.
Third generation machines were mainframe and minicomputers.
2.2.4 Fourth generation computers.

The fourth generation computers were a modification of the third generation computer’s technology. They used complex circuitry, an enhancement of the third generation computers. The design of this generation computers is based on Very large scale Integration (VLSI) and Large Scale Integration (LSI) technology which made it possible for a whole CPU to be fabricated in a single IC chip, giving rise to microprocessors and hence microcomputers. Microprocessors also moved out of the realm of desktop computers and into many areas of life as more and more everyday products began to use the microprocessors.

Fourth generation computers saw the development of GUIs, the mouse and handheld devices, and software applications like word processing, spreadsheets, Desktop publishing and so forth, became commercially available.

Microprocessor is a VLSI chip that contains all the electronic circuits required for the CPU of a digital computer. A digital system centered on a microprocessor is called a microprocessor based system. The microprocessor requires external memory chips, input and output chips and other host of external chips to create a fully working system. An example of a microprocessor based system is a microcomputer i.e. A computer whose CPU is a microprocessor.

Fourth generation include mainframe, minicomputer and microcomputers.

A typical microprocessor consists of:

1. ALU- a portion that performs operations such as addition, subtractions, comparison and logical operations.
2. A set of registers- used for data, instruction and results storage
3. Instruction decoder and control unit – for synchronization of operations within the computer system.
4. Bus system- for data transmission.
The size of the data word (word size), the number of available registers and the complexity and speed, with which the data can be manipulated all contributes to the power of a processor. Word size is the number of bits that the processor may process at any one time.
(a) **Microprocessor based system (microcomputer).**

A digital system centered on a microprocessor is called a microprocessor based system. The microprocessor requires external memory chips, I/O chips and other host of external chips to create a fully working system. An example of a microprocessor based system is a microcomputer; a computer whose CPU is a microprocessor. Functional units of a microcomputer are:

1. **I/O Port** – interfaces the computer system with the outside world.
2. **Input Devices** – Enables the microprocessor to receive input information (data and information).
3. **Microprocessor** – performs computation (arithmetic and logical operations and decision making).
4. **Memory** – used to store data and instructions.
5. **Output devices** - used to display the results processed by the microprocessor.
6. **Bus system** - these are used to interconnect various input, output and memories to the microprocessor.

The microprocessor system operates as dictated by the user. The user writes a sequence of instructions known as program and requests the microprocessor to begin executing each instruction starting from the first one. The microprocessor *fetches* the instruction one by one from the memory and *executes* them.
Figure 2.13a. 4th generation computers

Figure 2.13b. 4th generation computers
(b) Evolution of Microprocessor (4th generation computers)

<table>
<thead>
<tr>
<th>Company</th>
<th>Intel</th>
<th>Zilog</th>
<th>Motorola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-bit</td>
<td>4004</td>
<td></td>
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<tr>
<td>8-bit</td>
<td>8008</td>
<td>8080</td>
<td>6800</td>
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<tr>
<td></td>
<td>8085</td>
<td>6808</td>
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<tr>
<td>16-bit</td>
<td>8086</td>
<td>80186</td>
<td>68000</td>
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<tr>
<td></td>
<td>80286</td>
<td>68010</td>
<td></td>
</tr>
<tr>
<td>32-bit</td>
<td>80386</td>
<td>80486</td>
<td>68020</td>
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<tr>
<td></td>
<td>80586-Pentiums</td>
<td>Z8000</td>
<td>68030</td>
</tr>
<tr>
<td>64-bit</td>
<td>PowerPC</td>
<td>PI</td>
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<tr>
<td></td>
<td>PII</td>
<td>PIII</td>
<td>G3</td>
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<td></td>
<td>PIV</td>
<td>Duo Core/Core 2 Duo</td>
<td>G4</td>
</tr>
<tr>
<td></td>
<td>Core-i3, Core-i5, Core-i7</td>
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</tr>
</tbody>
</table>

Research shows that the trend in the computer's technological revolution is that there is:

(i) Continual decrease in computer size;
(ii) Improved speed and power of processing;
(iii) Decrease in cost of computers and its related facilities;
(iv) Number of components per circuit (IC) greatly increased, over 500,000 physical elements, e.g., transistors, capacitors, diodes, etc per chip (IC). (One Pentium II processor had about 14 million transistors), Mobile Intel® Pentium® 4 Processor supporting HT
Technology 538 has 125 million, Intel® Atom™ Processor 230 has 47 million transistors, Intel® Core™2 Duo processor P8700 has 410 million.

(c) Application areas for Microprocessors (and hence Computers).
Computers are used mainly in
(i) Measuring instruments e.g. C.R.O, multimeters, analyzers etc
(ii) Music related equipments such as synthesizers etc.
(iii) Households’ items such as microwave ovens, washing machines, television, mobile phones, etc.
(iv) Defense and military equipments such as fighter jets tanks, Missiles, radars etc.
(v) Medical equipments such as blood pressure monitors, blood analyzer etc.
(vi) Transportation, banks, speed control of motors, communications, business organizations, automobiles etc.

2.2.5 Fifth (5th) generation computers
Fifth generation computing devices, based on artificial intelligence, are already in use today. The use of parallel processing and superconductors is helping make artificial intelligence a reality. The goal of the fifth generation computing is to develop devices that responds to natural language input and are capable of learning self-organization.

Figure 2.14. Fifth (5th) generation computers
**Characteristics**

1) The fifth generation computers use super large scale integrated chips.
2) They have artificial intelligence.
3) They are able to recognize image and graphs.
4) Fifth generation computer aims to solve highly complex problem including decision making, logical reasoning.
5) Fifth generation computers are intended to work with natural language.
   Unlike the distinct changes from first to 4th generations, there is a grey line separating 5th and 6th generation computers.

### 2.3 TYPES OF COMPUTERS

There are a variety of computers, with a variety of their operational characteristics. The two basic types of computers, with respect to the computer's operational characteristics are analogue and digital computers.

#### 2.3.1 Analogue Computers:

They work on continuous process e.g. temperatures, pressure and speed. They are called continuous because they do not jump form one value to the next one. E.g. In a gas station gasoline pumps contain an Analog computer that converts fuel flow measurement into quantity and price values.

The examples of analogue devices include slide rule, car speedometer, and potentiometer. These are the computers that perform arithmetic operations and logical comparisons by measuring changes in physical magnitudes, e.g., electronic voltage, pressure changes, temperature changes, etc. These physical variations are analogous to the represented numerical values of the data being processed.

The application of analog computers is confined to specialized areas as in scientific or engineering experiments, manufacturing processes and military weapons, e.g., the temperature variations in a chemical process are converted into electronic voltage for analog computer's mathematical analysis.
2.3.2 Digital Computers
These are most commonly used type of computers and they take discrete data. They perform arithmetic operations and logical comparisons on digits (1's and 0's) and on other characters that have been numerically coded. They work on numbers i.e. discrete processes that are separate and countable. Every number, character, special symbol has a numeric value in the computer memory. These computers can process both numeric and alphabetic or alphanumeric data. The accuracy of digital computers is influenced by the memory size and the precision of the data input. These types of computers are used in a wider cross section of the application areas such as scientific, industrial and most of the other computer based data processing applications.

2.3.3 Hybrid Computers:
Hybrid computers are designed by interconnecting the digital computer and analog computers' element directly into one processor, using a suitable interfacing circuitry. That is both the digital and analog features are built within the same computer/processor. Hybrid computers are more advantageous because they combine both the functional capabilities of the digital and analog computers, though because of their capabilities they are more expensive.

2.4 CLASSIFICATION OF DIGITAL COMPUTER

2.4.1 Depending on Functions Performed
(a) Special Purpose Computers:
These digital computers are designed to carry out special processing tasks in one or more applications. In a computer network where the host computer serves several other computers or terminals/work stations connected to it, another specialised type computer known as the Front End Processor (FEP) may be used to specialise in the work of network control, i.e., controlling the data, instructions and the information communication between the various work stations and the host computer.
In modern offices, computers are used in typing and editing textual information. The computer is used to replace the use of the normal conventional typing machines such as the typewriter. In this computerised word processing, automatic typing and text editing is done by the special purpose computers described as the word processors.

(b) General Purpose Computers:
These are computers designed to be used in a variety of application environments as required. This capability of the computers is made feasible by passing into the computer the relevant sets of instructions, to be used by the computer to carry out the desired processing tasks at any given time.
The range of application areas for these computers is influenced by the volume of the data to be processed, the processing power of the computer, the information timing, i.e., when the information is required and the input/output facilities supported by the computer.
General-purpose computers can also be described as scientific computers if they have got the ability for high speed processing of numerical data of complex mathematical procedures.
General-purpose computers can also be described as business computers if they have got the ability of processing large volumes of data as in e.g., payroll, billing and other business applications.

(c) Dedicated Computers:
These are computers, which are capable of performing a variety of tasks in different application environments. In other words, dedicated computers are general-purpose computers that are committed to some processing tasks, though capable of a variety of tasks. A general-purpose computer, for example, can be dedicated to carry out word processing tasks.
2.4.2 Depending on processing capabilities (size)

(a) Microcomputers

This term microcomputer, originally used for an independent ‘free-standing’ computer, has become largely out-dated and replaced by the term personal computer (PC).

These are the most recent type of computer to be developed. In 1981 IBM introduced the PCs. They are the smallest types of computers. Conventional PCs have a full keyboard, a monitor, and can function as stand-alone systems. PCs can be categorized as:

(i) Pocket PCs/ Tablets

These are light, compact and highly portable. They have batteries and can operate with or without an external power source. The pocket PC, sometimes called a palmtop, can literally fit into a pocket or a handbag.

(ii) Laptop PCs

These, at about 3 kilograms, are slightly heavier than the pocket PC. They are often called a notebook PC because they are about the size of a thick notebook.

The power of the PC may not be related to its size. Some user conveniences must be sacrificed to achieve portability. For instance, input devices, such as keyboards and point-and-draw devices are given less space in portable PCs and may be more cumbersome to use. Portable computers take up less space and therefore have a smaller capacity for permanent storage of data and programs.

(iii) Desktop PCs/Tower PCs

Desktops and tower PCs are not portable because they rely on an outside power source and are not designed for frequent movement. Typically the desktop PC’s monitor is positioned on top of the system unit component. The processing component of the tower PC is designed to sit upright. The tower may be placed in any convenient location like a nearby shelf or on the desk.

One person at a time uses a PC. The user turns on the PC, select the software to be run, enters the data, and request the information. The PC like other computers is very versatile and has been used for everything from communicating business colleagues to controlling household appliances.

Unlike the large computers, the processor is contained on one silicon chip, instead of a combination of chips. This processor in a PC is called a microprocessor.
(b) **Mainframes**

Mainframe computers are large computers in terms of price, power and speed. Until the late 1960s, all computers were mainframe computers and they were expensive. In the late 1960’s computer vendors introduced smaller computers that were more affordable for smaller companies. These were called minicomputers.

Mainframe computers are designed specifically for the multi-user environment, in contrast to PCs which frequently are used as stand-alone computers. The amount of work that can be performed by the mainframe computer system is enormous primarily by the speeds of the input/output and storage devices.

Mainframe computers have very large processors with several hundred Gigabytes of RAM. This allows them to be used by many users at the same time.

This type of computer would usually be used with very large and fast peripheral devices and with many hard disk units. Used for processing and storage of data in organizations.

(c) **Minicomputers**

Originally used to describe computers, which were cheaper and less well equipped than mainframes, this term is becoming obsolete.

(d) **Supercomputers**

Supercomputers are used to process very large amounts of data very quickly. The speed of the supercomputer may be 100 times that of a large mainframe computer.

These are representative supercomputer applications:

- Enable the simulation of airflow around an airplane at different speeds and altitudes.
- Auto manufacturers use supercomputers to simulate auto accidents on video screens.
- Meteorologists employ supercomputers to study how oceans and the atmosphere interact to produce weather phenomena.
- Hollywood production use supercomputers to create the advanced graphics used to create special effects for movies and TV commercials.
- Others include genetic research centers, electrical power generation and control, missiles manufacturing and control centers, space research centers, etc.
3.0 COMPUTER COMPONENTS AND THEIR FUNCTIONS

A simple computer system comprises the basic components: processor (Control Unit and the Arithmetic and Logic Unit), Main Memory, Input Unit, Output unit and Storage Devices.

The diagram below shows how the above are connected together:

![Diagram of computer components](image)

**Figure 3.1. Components of computer system.**

3.1 MAIN PROCESSOR (OR CENTRAL PROCESSING UNIT, CPU).

This is the ‘brain’ of the computer. It consists of:

3.1.1 A group of registers

These are high speed storage locations that temporarily store data and instructions during processing. They may store a program instruction while it is being decoded, store data while it is being processed by the ALU, or store the results of a calculation.

Some of the Registers types
(a) **Memory Data Register**
It is located on the processor and it holds data waiting to be processed and information waiting to be processed.

(b) **Memory Buffer Register**
It is located on the memory chip and it holds data waiting to be processed and information waiting to be processed.

(c) **Program Counter/Sequential Control Register**
This stores the address of the location in which the next instruction to be fetched from memory is stored.

(d) **Memory Address Register**
It specifies the address in memory of the Location to be referenced by the control Unit.

(e) **Current Instructions Register/Instruction Register**
It stores the instruction which currently being processed

(f) **Accumulator**
It holds operands and results of the Arithmetic &Logic Unit operations

### 3.1.2 Control Unit
This is the device in charge of the operations of the computer and its peripherals. The control unit provides timing and harmonization for communication process between the CPU and the peripherals and any other circuits connected to the CPU. The control unit deciphers/decodes each instruction stored in it and then carries out the instruction. It directs the movement of electronic signals between main memory and the ALU. It also directs these electronic signals between the main memory and the input and output devices. For every instruction, the control unit carries out four basic operations, known as the *machine cycle*. In the machine cycle, the CPU,

1. Fetches an instruction  
2. Decodes the instruction,  
3. Executes the instruction and  
4. Stores the results.

The control unit receives requests in form of instructions from the main memory; it interprets/decodes the received instructions and responds with control influences that make the operation of the computer elements concerned to proceed as per the instruction's requirements.
It deals with each instruction in turns in a two-stage operation called the Fetch Execute Cycle.

### 3.1.3 Arithmetic and Logic Unit (ALU)

The arithmetic/logic unit performs the arithmetic, comparison, and logical operations. Arithmetic operations include addition, subtraction, multiplication, and division. Comparison operations involve comparing one data item to another to determine if the first item is greater than, equal to, or less than the other item. Logical operations work with conditions and logical operators such as AND, OR, and NOT.

The control unit issues out commands to the ALU, indicating where in main memory to get data to be manipulated, where to place the results achieved and how to interrelate the data.

Data about to be processed is taken from the Main Memory as directed by the control unit. Via Memory Data Register into the Accumulator. The ALU then performs the required operations on data as directed by the control unit. And then the results are stored in the Accumulator. They are later moved from the Accumulator and then stored in the Main Memory under the direction of the control unit and this process is called storing data.

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**Figure 3.2. CPU Processor chips**
There are different types of CPU from different companies. These include but not limited to:

Intel: 80386, 80486, Pentium, Pentium with MMX, Pentium II, Pentium III, Celeron, Pentium IV, Pentium Dual Core, Centrino, coppermine, core-i3, core-i7 etc

Motorola: 68000, PowerPC

AMD: Athlon, Duron, Thunderbird

Cyrix

They operate at different speeds e.g. 166MHz, 233MHz, 450MHz, 733MHz, 850MHz, 1.0 GHz, 2.4 GHz, 3GHz etc. The faster a CPU is, the faster it executes programs to accomplish tasks.

3.2 INPUT UNIT.

This is used to enter/capture data and programs (instructions), via a suitable device, into the computer systems. Before data can be used within a computer system, it is usually necessary to convert them into a format that supports processing by computer. Input devices convert data into a form that makes them machine-sensible. A modern computer makes use of a wide variety of input devices since data flowing into the organization or handled by an individual may take a number of different forms. The choice of an input device will often depend upon the type and the quantity of data to be entered. Entering data on a small scale is normally carried out by human operators using a number of familiar input devices, such as keyboard and mouse. However, large-scale data input may require the use of more specialized input devices. In many cases, a direct capture device will be used to acquire and store data automatically. Generally, the data are captured at source and stored with little or no human intervention. Data obtained from sensors on a production line, for example, might be stored and then processed automatically. There are a wide variety of types of input devices which include but not limited to; keyboards, mouse, toggle switches, microphones, digital cameras, scanners, magnetic encoders etc

3.2.1 Keyboard

Keyboard is the main form of input (allows numbers/alphabetical characters etc. to be entered directly). It has standard letters, numbers, punctuation found on a standard
typewriter plus a number of specialized keys. It is the most common input devices used with computer system.

When you look at all the extras and options that are available for new computer keyboards, it can be hard to believe that their original design came from mechanical typewriters that didn't even use electricity. Now, you can buy ergonomic keyboards that bear little resemblance to flat, rectangular models with ordinary square keys. Some flashier models light up roll up or fold up, and others offer options for programming your own commands and shortcuts.

![An average Windows keyboard.](image)

Keyboards use switches and circuits to translate a person's keystrokes into a signal a computer can understand.

A keyboard's primary function is to act as an input device. Using a keyboard, a person can type a document, use keystroke shortcuts, access menus, play games and perform a variety of other tasks. Keyboards can have different keys depending on the manufacturer, the operating system they're designed for, and whether they are attached to a desktop computer or part of a laptop. But for the most part, these keys, also called keycaps, are the same size and shape from keyboard to keyboard. They're also placed at a similar distance from one another in a similar pattern, no matter what language or alphabet the keys represent. Most keyboards keys includes:

- **Typing keys:** The typing keys include the letters of the alphabet, generally laid out in the same pattern used for typewriters. This layout is known as QWERTY for its first six letters.
Keyboards can also use a variety of other typing key arrangements. The most widely known is Dvorak, named for its creator, August Dvorak. The Dvorak layout places all of the vowels on the left side of the keyboard and the most common consonants on the right. The most commonly used letters are all found along the home row. The home row is the main row where you place your fingers when you begin typing. People who prefer the Dvorak layout say it increases their typing speed and reduces fatigue. Other layouts include ABCDE, XPeRT, QWERTZ and AZERTY. Each is named for the first keys in the pattern. The QWERTZ and AZERTY arrangements are commonly used in Europe.

✦ The numeric keypad is a more recent addition to the computer keyboard. As the use of computers in business environments increased, so did the need for speedy data entry. Since a large part of the data was numbers, a set of 17 keys, arranged in the same configuration found on adding machines and calculators, was added to the keyboard.

✦ Control keys: In 1986, IBM further extended the basic keyboard with the addition of function and control keys. Applications and operating systems can assign specific commands to the function keys. Control keys provide cursor and screen control.
Four arrow keys arranged in an inverted $T$ formation between the typing keys and numeric keypad move the cursor on the screen in small increments.

Other common control keys include: Home, End, Insert, Delete, Page Up, Page Down, Control (Ctrl), Alternate (Alt) and Escape (Esc).

The Windows keyboard adds some extra control keys: two Windows or Start keys, and an Application key. Apple keyboards, on the other hand, have Command (also known as "Apple") keys.

3.2.2 Pointing Devices

A "pointing device" can also refer to a special "stick" (sometimes telescopic, to reduce the length when not in use), or a lamp with a narrow light beam that is pointed at a map, blackboard, slide screen, movie screen, etc.; sometimes the light is in the form of an arrow.

One of the most natural of human gestures, the act of pointing, is incorporated in several kinds of input devices. Computer pointing devices control the position of the cursor or pointer on the screen. Pointing devices include the mouse and its variant, the touch screen, trackballs, and various forms of pen input.
(a) The mouse and its variants.

(i) Mouse

The principal pointing toll used with microcomputers is the mouse. It is a device that is rolled about on a desktop to direct a pointer on the computer’s screen. It is used with computers that use Graphical User Interface (GUI). (( GUI allows the user to control the operation of a computer program or item of computer hardware using a pointing device such as a mouse by selecting options from icons and menu options). The pointer is a symbol, usually an arrow that is used to select items from a list (menu), on the screen or to position the cursor. The cursor, also called insertion point, is the symbol on the screen that shows where data may be entered next, such as text in a document. It is vital for intuitive drawing/graphics operations. A mouse eliminates the need to type computer commands. Instructions are given by the user to the computer by pointing an arrow or pointer on the screen to a picture or word and then clicking the button on the mouse.

Some mice have a scroll wheel between the buttons:

Some mice have no ball underneath, instead they have a light. They do not need to be cleaned as often, do not wear out. Many of these work with special mouse pads and are more accurate than ball mouse...good for sensitive drawings

Some mice are cordless.
(ii) **Trackball**

This is a movable ball, mounted on top of a stationary device, that can be rotated using fingers or palm or the trackball is a ball inserted in a small external box near the keyboard. The ball is rolled with the fingers to move the mouse cursor. Some people like to think of the trackball as an upside-down. *It is a kind like an upside-down mouse.* The ball is controlled usually by thumb and one finger and is used as a replacement for a mouse.

A trackball is not as accurate as a mouse, and it requires more frequent cleaning, but it is a good alternative when desktop space is limited.

(iii) **Pointing Stick/ Track points**

A pointing stick looks like a pencil eraser protruding from the keyboard between the G, H and B keys. One move the pointing stick with the finger while using the thumb to press buttons located in front of the space bar. A forerunner of the pointing stick is the joystick, which consists of a vertical handle like a gearshift lever mounted on a base with one or two buttons. Pointing sticks are used on laptop computers.

(iv) **Track pad (Touch pad)**

This is a small, flat surface over which you slide your finger using the same movement one would with a mouse. The cursor follows the movement of the finger. One “clicks” by tapping the finger on the pad’s surface or by pressing buttons positioned close by the pad.
Touch pads are also most often found on laptop computers. (The track pad has no moving parts. One simply moves a finger about a small touch sensitive pad to move the mouse cursor).

**(v) Touch screen**

A touch screen is a video display screen that has been sensitized to receive input from the touch of a finger.

The screen is covered with a plastic layer, behind which are invisible beams of infrared light. One can input a request for information by pressing on buttons or menus displayed (Users make selection and control programs by pressing onto the screen). The answers to the request are displayed as output in words or pictures on the screen. These screens are normally used in kiosks, ATMs, airport tourist directories, hotel TV screens (for guest checkout), department store, tablets, laptops, cell phones etc.

*The function of a touch sensitive screen is similar to that of the light pen except that it is activated by the operator touching the screen instead.*

![Figure 3.9. Touch sensitive screen](image)

**(b) Pen Input**

Some input devices used variations on an electronic pen. Examples are pen-based systems, light pens and digitizers.

**Pen-based computer systems**

Pen-based computer systems allow users to enter handwriting and marks onto a computer screen by means of a penlike stylus rather than by typing on a keyboard. Pen computers use handwriting recognition software that translates handwriting characters made by the pen, or stylus, into data that is usable by the computer. Many handheld computers and PDAs have pen input, as do digital notebooks.
(ii) **Light Pen**

Light pen is a light sensitive stylus, or pen-like device, connected by a wire to the computer terminal. The light pen allows the operator to identify a particular point or character displayed on the screen, and can be used alone or in conjunction with a keyboard to add, rearrange or delete information displayed on the screen. The user brings the pen to a desired point on the display screen and presses the pen button, which identifies that screen location to the computer. Light pens are usually used by graphic designers, engineers, illustrators or on PDAs.

![Light Pen Image](image)

Figure 3.10. *Light pen*

(iii) **Digitizer**

A digitizer uses a mouse-like copying device called a puck, or an electronic pen, which can convert drawings and photos to digital data. One form of digitizer is the digitizing tablets also called a graphics tablet consists of a flat, rectangular, electronic plastic board used to input drawings, sketches, or other graphical data. Each location on the graphics tablet corresponds to a specific location on the screen. When you draw on the tablet with either an electronic pen or a puck, the tablet detects and converts the movements into digital signals that are sent into the computer. A puck is a device that looks similar to a mouse, except that is has a window with cross hairs so the user can see through to the tablet. Digitizing tablets are often used to make maps and engineering drawings.

(c) **Source Data-Entry Devices**

Source data-entry devices create machine-readable data on a magnetic media or paper or feed it directly into the computer’s processor.
Source data-entry devices do not require keystrokes (or require only a few keystrokes) to input data into the computer. Rather data is entered directly from source, without human intervention. Examples include:

- Scanning devices (e.g. imaging systems, bar-code readers, mark-a and character-recognition devices, and fax machines),
- Audio-input devices, web cameras and video input, and photographic input (digital cameras),

(i) Scanning devices-imaging systems

A scanner is a device, which use light-sensitive equipment to translate/converts text, drawings, photos (graphics) and the like directly into machine language. It is similar to a copy machine except that it creates a file of the document instead of a paper copy. In text scanning each character is compared to known shape or pattern so that the appropriate code for that character can be entered into a computer. If a character cannot be recognized then a special unknown character is input for the user to edit with the correct text.

Some scanners have spell checking facilities and in this case there is no need of typing the text.

In graphic scanning the pattern of light and dark images on a page is converted into a series of dots called picture elements or pixels and these can be stored as binary digits in a computer memory.

Scanned images or texts can then be processed by a computer, displayed on a monitor, stored on a storage device or transmitted to another computer.

Scanned photos can be used in brochures while the scanned documents can be faxed or saved on a hard disk for records. There are many varieties of scanners depending on resolution (i.e., picture quality) and mode of operation.
Scanners types

**Drum Scanner** - A drum scanner is usually found in a professional printing business, because they provide the highest level of image quality available. They are used with a cylindrical drum that rotates past sensing elements to complete scanning jobs. They are more on the expensive side and they are much more advanced than typical desktop scanning.

**The flatbed scanner** is the most popular type, and the flat desktop design gives you a lot of scanning area. Items to be scanned are placed on a glass plate, like a copier, so one can scan multiple items of various shape and sizes, with the largest paper size being either a letter or legal page, depending on the model. Some models even include a transparency adapter to scan slides, x-rays or other transparent originals. Flatbed scanners are highly recommended, if the user is going to scan a good number of graphics or separate pieces of text. Flatbed scanners are available with a SCSI, Parallel Port or USB Port Connector.

**Sheet fed Scanner** is fed a piece of paper into it, much like a fax machine. Sheet fed scanners can only handle one piece of paper at a time, although some models come with built-in automatic document feeder (ADF) to scan multiple pages unattended.

**Lightshow 3D Object Scanning** System allows you to use flatbed scanner to scan 3D objects, paper documents, photographs, transparencies, positives, negatives, and x-rays. The LIGHTSHOW 3D Object Scanning System uses the high resolution capabilities of existing flatbed scanner to create sharp, crisp, accurate details of 3D objects.

**Film (Photo) scanners** used for scanning of photo pictures, slides and input images to computer.
**Portable/Handheld scanners:** With portable sheet-fed color scanning devices scanner, the USB port connection feature allows one to have one-cable hook up to a notebook or desktop PC.

*Figure 3.16.*

*C-Pen 20* scans text, numbers and small images from printed or hand-printed sources. Line by line the data is sent into the document management system.

**Digital Cameras:** Digital cameras are a versatile tool that can produce superior quality images. Though slower and more difficult to use than user types of scanners, digital cameras are adaptable to a wide array of documents and objects. Most fragile materials can be safely captured, though the need to provide external lighting means. Digital camera technology continues to improve, helped along by the growing consumer market.

**(ii) Scanning devices-bar code readers**

Bar encoding is a special type of point-of-sale data recording. Although several different bar codes exist, the most easily recognizable is the Universal Product Code (UPC). Bar-code readers are photoelectric (optical) scanners that translate the symbols in the bar code into digital. The bar code reader has a scanning device that translates black and white (or light and dark) bars of different widths into electrical impulses. Thus, there is no need to manually use a data entry device such as a cash register to key the data into machine-readable form.

These are used to read in product codes quickly and without error especially in supermarkets, grocery stores etc. They are also used for security cards.

*Figure 3.17.*

*Figure 3.18.*
Application

- Stock control/accounting.
- Library.
- Supermarket point of sales.

Advantages

- Cost effective.
- High accuracy reading.
- Allow easy change of information in CPU.

Disadvantages

- Not easy to change information on bar code.
- Easy tampering.
- Not human readable.

(iii) Scanning devices – marks-recognition and character-recognition devices:

There are three types of scanning devices that senses marks or characters. They are usually refereed to by their abbreviations OCR, OMR, and MICR.
**Optical Character Recognition (OCR)**

Optical character recognition (OCR) is a technology that involves reading typewritten, computer-printed, or handwritten characters from ordinary documents and translating the images into a form that the computer can understand. Most OCR devices include a small optical scanner for reading characters and software for analyzing what is read.

**Typical rules for making Handwritten Characters Readable by OCR**

1. **Data typed, hand-written on source document.**

   - **Rule**
   - **Acceptable**
   - **Unacceptable**

<table>
<thead>
<tr>
<th>Rule</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make letters big.</td>
<td>REDFORD</td>
<td>REDFORD</td>
</tr>
<tr>
<td>2. Use block letters.</td>
<td>ROBERT</td>
<td>Robert</td>
</tr>
<tr>
<td>3. Carefully connect lines</td>
<td>571</td>
<td>571</td>
</tr>
<tr>
<td>4. Close loop.</td>
<td>9086</td>
<td>9086</td>
</tr>
<tr>
<td>5. Do not link characters.</td>
<td>ROBERT</td>
<td>ROBERT</td>
</tr>
</tbody>
</table>

2. **Data in special font.**

3. **Compare pattern sensed with those stored in the machines.**

4. **Assume character that matches closely to the read character.**

---

*Figure 3.20.*

This portion is returned with payment.

OCR characters indicate amount due and account number.
OCR is used frequently with turn-around documents. With this gas bill, you tear off the top portion and return it with your payment

**Application:**
- Turnaround documents.
- Sales orders.
- Purchase orders, etc.

**Speed:**
- 50 - 3000 character per second.
- 200 - 1200 documents per minutes for specified source documents.

**Advantage**
- The input is both man and machine-readable
- It enables documents to be read directly without the state of human intervention in keying in.

**Disadvantages**
- Initial cost of the system is very high
- A character can be mistaken for another and those that are not recognized are rejected
- Slow reading.

**(II) Optical Mark Reader (OMR)**

This technique involves the use of standard preprinted documents on which horizontal marks are made with a pencil in predetermined positions. The position of each mark is determined by dividing the form into areas or boxes printed in distinct color. Each mark has a meaning, which is independent on its position. Directing thin beams of light on to the paper surface it will be reflected back unless it is absorbed by the black pencil mark.

**Applications**
- Examinations answer sheets.
- Order forms.
- Surveys.

**Advantages**
- Straightforward.
- Misreading less likely.
Disadvantages

- Limited uses as not all data can be coded into marks.
- Unsuitable for alphabetical data.
- Require clear printing to explain marks made.

(III) Magnetic Ink Character Reader (MICR)

Magnetic Ink Character Recognition (MICR) is a technology that allows details from bank cheques to be read into a computer quickly and accurately. This method is widely used in the banking industry and it uses characters, which are printed with ink containing magnetic material. When the characters are being read they are first passed through a magnetic field and then the reader recognizes each character by its unique magnetic field pattern. E.g. in banks a cheque book is given to a customer with each cheque pre-encoded with a cheque serial number, bank codes, and Customer Account Numbers.

Once the cheque is passed to the bank the amount is post encoded manually and the cheque can then be read.
The characters printed on the cheque include the bank number, the account number, and the cheque number. The amount of the check in the lower-right corner is added after one writes the check.

*With all these information, cheques can then be processed/cleared at very high speed.*

**Advantages**
- Forging is not easy.
- Accurate reading.

**Disadvantages**
- Proper care of documents necessary.
- Limited data.
- Data located in pre-determined position.

**Scanning devices – fax machines**

A fax machine or facsimile transmission machine – scans an image and sends it as electronic signals over telephone lines to a receiving fax machine, which prints out the image on paper. There are two types of fax machines- dedicated fax machine and fax modems.

(I) Dedicated fax machines are specialized devices that do nothing except send and receive fax documents. These are what we usually think of as fax machines. They are found not only in offices and homes but also alongside regular phones in public places such as airports.

(II) A fax modem is installed as a circuit board inside the computer’s subsystem cabinet. It is a modem with fax capability that enables one to send signals directly from the computer to someone else’s fax machine or computer fax modem. With this device, one does not have to print out the material from the printer and then turn around and run it through the scanner on a fax machine. The fax modem allows the user to send information more quickly than if one had to feed it page by page into a machine. The fax modem is another feature of mobile computing; it’s especially powerful as receiving device. Fax modems are installed inside portable computers, including pocket
PCs and PDAs. If one links up a cellular phone to a fax modem in the portable computer, one can send and receive wireless fax messages no matter where one is in the world. The use of fax machines has declined in the recent to the advancement in the mobile phone technologies.

(d) **Voice Data Entry (VDE) – Voice-recognition systems and Audio input devices**

*A voice recognition system*, using a microphone (or telephone) as an input device, converts a person’s speech into digital signal by comparing the electrical patterns produced by the speaker’s voice with a set of prerecorded patterns stored in the computer. The sounds are converted into digital form and are either stored in a media e.g. a magnetic tape or it is entered into a computer directly for processing. When the system is to be used, an operator using the system keys in a word which he wishes the system to recognize by saying then the sound is converted to binary form. Microphones are used to convert the initial human voice into electrical signals (voltages). Voice-recognition systems have had to overcome many difficulties, such as different voices, pronunciations, and accents.

*Audio input devices* - records analogue sound and translates it for digital storage and processing.

An audio signal can be digitized in two ways- by an audio board or a MIDI board. Analogue sound from a cassette player or a microphone goes through a special circuit board called an audio board (or sound card). An audio board is an add-on circuit board in a computer that converts analogue sound to digital sound and stores it for further processing and /or plays it back, providing output directly to speakers or an external amplifier.

A MIDI board- MIDI, pronounced “middle,” stands for Musical Instruments Digital Interface- provides a standard for interchange of musical information between musical instruments, synthesizers, and computers.

**Application**

- Assisting handicapped.
- Security.
Artificial Intelligence.

**Advantage**
- Can be operated by a person without Keyboard knowledge
- It’s very fast

**Disadvantage:** Accents and dialects

(e) **Digital Cameras**
A digital camera uses a light-sensitive processor chip to capture photographic images in digital form on a small diskette inserted in the camera or on flash memory chips. A digital camera allows one to take pictures and store the photographed images digitally instead of on traditional film. With some digital cameras, one downloads, or transfers a copy of, the stored pictures to the computer by connecting a cable between the digital camera and the computer and using special software included with the camera. Operating systems like Windows XP to the newer ones do facilitate downloading without using the special camera software. With other digital cameras, the pictures are stored directly on storage media such as a floppy disk, PC Card, or flash card.

![Figure 3.23.Digital cameras](image)

(i) **PC cameras:** These come from different companies with different resolutions, features, use different software and have different connections (parallel, USB etc...!!!)

![Figure 3.24.](image)

(ii) **Web cam** is a camera that attaches to a computer to record moving images that can then be posted on a website in real-time.
(iii) **Video-input cards**- as with sound, most film and video tapes are in analogue form; the signal is a continuously variable wave. For computer use, the signal that comes from a VCR or a camcorder must be converted to digital form through a specialized digitizing card—a video-capture card—that is installed in the computer. Two types of video cards are frame-grabber video and full-motion video. Frame-grabber video cards can capture and digitize only a single frame at a time. Full-motion video cards can convert analogue to digital signals at the rates of up to 30 frames per second, giving the effect of continuously flowing motion picture.

(f) **Joysticks and Gamepads**
A joystick is typically used for game playing but can also be used to enter user requests. This device enables the user to interact with screen image by moving the stick in multidirections. It is commonly used to play computer games.

![Figure 3.25 Joy stick](image)

(g) **Sensors:**
A sensor is an input device that collects specific data directly from the environment and transmits it to a computer. Although you are unlikely to see such input devices connected to a PC in an office, they exist all around us, often in nearly invisible form. Sensors can be used to detect all kinds of things: speed, movement, weight, pressure, temperature humidity, wind current, fog, gas, smoke, light, shapes, and images and so on.
Sensors are used to detect the speed and volume of traffic and adjust traffic lights. They are used on mountain highways in winter-time as weather-sensing devices to tell workers when to roll out snowplows. In some areas, sensors have been planted along major earthquake fault lines in and experiment to see whether scientists can predict major earth movements. In aviation, sensors are used to detect ice buildup on airplane wings or to alert pilots to sudden changes in wind direction.

(h) Radio-frequency identification devices:
Also known as RF-ID tagging, radio-frequency identification technology is based on an identifying tag bearing a microchip that contains specific code numbers. These code numbers are read by the radio waves of a scanner linked to a database. Drivers with RF-ID tags can breeze through the tollbooths without having to even roll down their windows; the toll is automatically charged to their accounts. Radio-readable ID tags are also used by the Postal Service to monitor the flow of mail, by stores for inventory control and warehousing, and in the railroad industry to keep track of rail cars. They are even injected into dogs and cats, so that veterinarians with the right scanning equipment can identify them if they become separated from their owners.

(i) Human biology-input devices:
Characteristics and movements of the human body, when interpreted by sensors, optical scanners, voice recognition, and other technologies, can become forms of input. Two examples are biometric systems and line-of-sight systems.

(i) Biometrics is the science of measuring individual body characteristics. Biometric security devices identify a person through a fingerprint, voice intonation, or other biological characteristic. For example, retinal-identification devices use a ray of light to identify the distinctive network of blood vessels at the back of the eyeball.

(ii) Line-of-sight systems enable one to use the eyes to point at the screen. This technology allows some physically disabled users to direct a computer. One can operate a computer by focusing on particular areas of a display screen. A camera mounted on the computer analyzes the point of focus of the eye to determine where the person is looking. One can operate to computer by looking at icons on the screen and “press a key” by looking at one spot for a specified period of time.
3.3 OUTPUT UNIT

This unit is used to give out (display) information (result of processed data). Some commonly used output devices are character/page printers, monitors (cathode ray tubes, CRT and liquid crystal displays, LCD), speakers, graph plotters, etc.

The operation of input/output devices is done via an input/output controller (or input/output port). An input/output port controls the operation of peripheral according to commands received from the CPU. It provides the CPU with information about the status of the devices and coordinates the flow of data between external bus and the device. Two or more devices may share the same input/output controller.

The quality of a computer system can be best assessed by the quality of the output it generates. The essence of designing and implementing a data processing system is to generate desirable output.

Text consists of characters that are used to create words, sentences, and paragraphs. A character is a letter, number, punctuation mark, or any other symbol that requires one byte of computer storage space.

Graphics are digital representations of non-text information such as drawings, charts, and photographs.

Audio includes music, speech, or any other sound. To store such sounds, a computer converts the sounds from a continuous analog signal into a digital format. Most output devices require that the computer convert the digital format back into analog signals.

Video consists of images that are played back at speeds that provide the appearance of full motion. Video often is captured with a video input device such as a video camera.

3.3.1 Display Devices

A display device is an output device that visually conveys text, graphics, and video information. Information shown on a display device often is called soft copy, because the information exists electronically and is displayed for a temporary period of time. Display devices include CRT monitors, flat-panel displays, and high-definition televisions.
(a) **CRT Monitors**

A CRT monitor, or monitor, is a display device that consists of a screen in a plastic or metal case.

Monitors that display only one colour are considered as **monochrome**.

The core of a CRT monitor is a large glass tube called a cathode ray tube (CRT). The screen, which is the front of the tube, is coated with tiny dots (pixels) of phosphor material that glow producing an image on the screen when electrically charged by an electron beam.

![Figure 3.26a.](image)

(b) **Flat-Panel Displays**

A flat-panel display is a lightweight, thin screen that consumes less power than a CRT monitor. Common types of flat-panel displays includes LED, LCD and gas plasma.

(i) **LCD Displays**

LCD displays commonly are used in laptop computers, handheld computers, digital watches,’ and calculators because they are thinner and more lightweight.

It uses a liquid crystal display (LCD), which has special molecules (called liquid crystals). When an electric current passes through them, they twist, causing some light waves to create the desired images on the screen.

![Figure 3.26b.](image)
Introduction to computers

(ii) Gas Plasma Monitors
Used for larger displays while hanged on a wall. Gas plasma monitors use gas plasma technology, which substitutes a layer of gas for the liquid crystal material in an LCD monitor. When voltage is applied, the gas glows and produces the pixels that form an image.

(c) 3D Headsets
These are used in virtual reality

Characteristics of display devices
Screens are made up of pixels - picture elements (i.e. dots). Pixels are the smallest electronic elements that compose digital pictures.
All display devices have these common features:
(i) Size: length of diagonal of monitor (sometimes viewable length, sometimes tube length). Common values are 15", 18", 19", 21", 24", 27", etc
(ii) Dot pitch: size of a single dot on the screen (0.23mm, 0.24mm, 0.26mm, 0.28mm are common ), smaller is more crisp/less blurry.
(iii) Refresh options: interlaced (every second row shown first) vs. non-interlaced refresh rate 60Hz, 72Hz, 90Hz
(iv) Maximum resolution: number of columns and rows of pixels (common values are 640x480, 800x600, 1024x768, 1280x1024). Better resolutions are today possible.

(d) Video card:
This required for every computer that uses graphics. Many new ones have 3D acceleration features.
3.3.2 Computer Output On Microform (Com)

This method of output provides photographed type of computer output onto the microform. The microforms are photographically reduced documents on films (magnetic media) peruse photo negative for more insight.

There are two forms of the microform, the

(a) Microfilm, which is a film reel of 16mm roll.

(b) Microfiche which is rectangular shaped measuring about 105 by 148mm sheet.

Both the microfilm and microfiche are small and store several pages of A4 sized information, about 3000 and 98, A4 pages respectively.

The computer displays the results onto the screen whose contents are then photographed onto the microform, an on-line operation. Alternatively, the computer outputs the results into a storage medium, e.g., the magnetic tapes, whose contents are read by a transcriber’s machine and displays them onto the screen connected to the machine. The contents being displayed on the screen are then photographed onto the microform. The transcribers machine is not under direct influence of the computer hence this gives an off-line operation.

Advantages

- Saves on stationery and space;
- Faster than printing;
- Non-bulky hence conveniently transportable;
- The microform contents are not easily read using naked eyes, hence guaranteeing the security of the reports;
- Have got longer life span as compared to e.g., paper medium output;

Disadvantages

- They are expensive.
- Cause eyestrain if an attempt is made to read the microform contents;
Additional equipments for viewing the contents of the microform and for producing full sized copies are required.

**Application**
The COM is conveniently used where the application generates voluminous output and use of update is not frequently necessary. The COM is used for example in:
- Libraries for books, catalogues, references;
- To retain, e.g., town plans, maps, statistics, etc, in government authorities;
- In banks, insurance companies, etc, to store personnel or customer's records and so on.

### 3.3.3 Graph Plotters
These are output devices that produce graphical output, e.g., diagrams, maps and such like outputs. The commonly commercially available graph plotters are the Flat Bed Plotter and the Drum Plotter. These names are derived from the surface onto which stationery has to be placed.

(i) **The Flat Bed Plotter** has a flat surface, 'bed' onto which the stationery is placed for the pen to be moving over it in all directions to produce graphical output.

(ii) **The Drum Plotter** has got the 'drum' onto which the stationery is placed for the drawing to be possible. The drum rolls the stationery, forwards or backwards, as the pen moves over it to produce graphical output.

Graph plotters are applied basically in Computer Aided Design (CAD) and architectural designs. In both the cases, the computer is used to form the graphical design and output it through the graph plotters. The graphs plotters operate at slow speeds hence are normally connected in an off-line mode to avoid wasting the computer time.

### 3.3.4 Magnetic Media
The computer output/information from the computer memory can also be directed into the magnetic storage media, e.g., the tape or disk, instead of being printed or displayed. Such output directed to any of the magnetic storage media are thus magnetically coded. Directing the computer output into magnetic media is usually necessary where such results/output of processing is to be stored for future retrieval and/or further processing.
3.3.5 Voice Output

The information from the computer memory, which is in electronic form, is transformed to wave forms, through various specialised additional circuitry, for the recipients of such information to hear.

Uses of this Method

✧ Voice output is useful where reading is not necessary or is impossible
✧ Fast output is required
✧ As learning aids
✧ Emergency situations
✧ Answering services
✧ Post office talking clock

Disadvantages

✧ It is non-permanent
✧ It may be boring for prolonged output.

3.3.6 Printers

A printer is an output device that produces text and graphics on a physical medium such as paper or transparency film. Printed information is called hard copy (printout) because the information exists physically and is a more permanent form of output. Generally, printers can be grouped into two categories: impact and non-impact.

(a) Impact Printers

An impact printer forms characters and graphics on a piece of paper by striking a mechanism against an ink ribbon that physically contacts the paper. Because of the striking activity, impact printers generally are noisy.

Two commonly used types of impact printers are dot-matrix printers and line printers. Each of these printers is discussed in the following sections.

(i) Dot-Matrix Printers

A dot-matrix printer is an impact printer that produces printed images when tiny wire pins on a print head mechanism strike an inked ribbon. When the ribbon presses against the paper, it creates dots that form characters and graphics.
A dot-matrix printer produces printed images when tiny pins strike an inked ribbon.

(ii) Line Printer
A line printer is a high-speed impact printer that prints an entire line at a time. It prints fully formed characters when hammers strike a horizontal, rotating band that contains shapes of numbers, letters of the alphabet, and other characters.
(b) **Non-impact Printers**

A no impact printer forms characters and graphics on a piece of paper without actually striking the paper. Some spray ink, while others use heat and pressure to create images. Three commonly used types of no impact printers are ink-jet printers, laser printers, and thermal printers.

(i) **Inkjet printers**

An ink-jet printer is a type of no impact printer that forms characters and graphics by spraying tiny drops of liquid ink onto a piece of paper. One factor that determines the quality of an ink-jet printer is its resolution, or sharpness and clarity. Printer resolution is measured by the number of dots per inch (dpi) a printer can output. The higher the dpi, the better the print quality. With an ink-jet printer, a dot is a drop of ink. A higher dpi means the drops of ink are smaller, which provides a higher quality image. Most ink-jet printers have a dpi that ranges from 300 to 1,440 dpi. Typically, printers with a higher dpi are more expensive.

(ii) **Laser Printers**

A laser printer is a high-speed, high-quality no impact printer. When printing a document, laser printers process and store the entire page before they actually print it. A laser printer creates images using a laser beam and powdered ink, called toner. The laser beam produces an image on a special drum inside the printer. The light of the laser alters the electrical charge on the drum wherever it hits.

When this occurs, the toner sticks to the drum and then is transferred to the paper through a combination of pressure and heat.

![How a Laser Printer Works](image-url)
(iii) **Thermal Printers**

A thermal printer generates images by pushing electrically heated pins against heat-sensitive paper. Standard thermal printers are inexpensive, but the print quality is low and the images tend to fade over time. Thermal printers are, however, ideal for use in small devices such as adding machines.

(iv) **Special-Purpose Printers**

Other printers have been developed for special purposes.

I. **A photo printer** is a color printer designed to produce photo lab quality pictures directly from a digital camera. A label printer is a small printer that prints on an adhesive-type material that can be placed on a variety of items such as envelopes, disks, audiocassettes, photographs, and toys. Many label printers are used to print bar codes.

II. **Plotters and Large-Format Printers.** Plotters and large-format printers are sophisticated printers used to produce high-quality drawings such as blueprints, maps, circuit diagrams, and signboards. These printers are used in specialized fields such as engineering, drafting, and graphic arts.

3.3.7 **Audio Output**

Audio is music, speech, or any other sound. Audio output devices are the components of a computer that produce music, speech, or other sounds, such as beeps. Two commonly used audio output devices are speakers and headsets.

(a) **Speakers:** These are used to produce sound outputs. They come in many varieties (differing quality, wattage etc...). Sometimes built-in to the monitor or computer case.
3.3.8 Data Projectors
A data projector takes the image that displays on a computer screen and projects it onto a screen so that an audience of people can see the image clearly.

3.3.9 Output Devices for Physically Challenged Users
The growing presence of computers in everyone’s lives has generated an awareness of the need to address computing requirements for those with physical limitations. For users with mobility, hearing, or vision disabilities, many different types of output devices are available. Hearing-impaired users, for example, can instruct programs to display words instead of sounds. With Windows, such users also can set options in the Accessibility Properties dialog box to instruct Windows to display visual signals in situations where normally it would make a sound.

Visually impaired users can change Windows settings such as increasing the size or changing the color of the text to make the words easier to read. Instead of using a monitor, blind users can utilize speech output, where the computer reads the information that displays on the screen. Another alternative is a Braille printer, which outputs information in Braille onto paper.
3.4 MEMORY [STORAGE DEVICES]

A storage device accepts data, stores them and releases them on demand at a later time. There are two main types of storage devices used in modern computers, namely primary memory (main memory) and secondary memory (backing storage).

There are mainly two types of memories:-

3.4.1 Main Memory (Main Storage)

These are made up of semiconductor memories, which are relatively fast but expensive. Examples are Random Access Memory (RAM) and Read Only Memory (ROM).

(a) RAMs

RAMs are used in computers for the temporary storage of programs and data. Data can be written to and read from RAM easily. They store information or data so long as the power is on; hence it is volatile.

Since it is easy to change the contents of a RAM, RAMs are the working memory of a computer system (where data is manipulated). Types of RAMs include; Static RAM (SRAM) and Dynamic RAM (DRAM).

(b) ROMs

The information stored in a ROM can only be read but cannot be altered during normal operations. The information is not lost when power goes off and hence ROMs are non-volatile. ROMs are designed to hold data that are either permanent or will not change frequently. Programs stored in ROM are called firmware. Type of ROMs includes MROM, PROM, EPROM, and EEPROM.

The more the memory, the more the programs a user can run at once. They often translate to faster computer. They come in different capacities (512MB, 2GB, 4GB, 8GB, 16GB, and even 32 GB) and different types/speeds or models (EDO, SDRAM, cache).
(c) **Flash memory**

Another type of non-volatile memory is called flash memory or flash ROM. Flash memory can be erased electronically and reprogrammed. Flash memory is used to store programs on personal computers, as well as cellular telephones, printers, digital cameras, pagers, and personal digital assistant.

(d) **CMOS**

Complementary metal-oxide semiconductor (CMOS) memory is nonvolatile memory used to store configuration information about the computer, such as the type of disk drives, keyboard, and monitor; the current date and time; and other startup information needed when the computer is turned off. CMOS use battery power to retain information even when the power to the computer is turn off.

(e) **Cache Memory:**

This is a high-speed memory. The speed of cache memory compares to that of the CPU. The cache memory for its speed therefore is used to interface the slow communicating main memory to the CPU. The cache memory therefore acts as a buffer that receives the data, instructions and/or information from the main memory, at the speed of the main memory and remits them to the CPU at the speed of the CPU and vice versa. Note that this consideration isolates the memory from the CPU.

The cache memory is usually used in large computer systems, which ever the case it speeds up the rate of processing by easing communication between the CPU and the main memory, that is the movement of data and instructions to the CPU and remitting back to the main memory of the intermediate results. The cache memory design is based on the semiconductor elements.

3.4.2 **Secondary (auxiliary or Backup or mass storage)**

These are used to supplement the main memory and are external to the main computer. They have the capacity to store millions of information, without the need of electrical power. They provides storage for programs and data not currently being executed (operated on), but which will be transferred to the main storage (RAM) when required.
In comparison to the main memory, the mass memory storage device;

- are cheap
- has high storage capacity
- are non-volatile (store information more permanently)
- are very slow

Commercially available storage devices are mostly magnetic based, e.g. magnetic tapes, magnetic disks, and cassettes. Other devices use optical techniques e.g. CDROMs etc.

(a) Magnetic Disk Storage

Magnetic disk drives are comprised of one or more circular rotating disks coated with magnetic material that is used for the recording of data.

Data are recorded into concentric rings known as tracks. A track is sub-divided into sectors.

*Figure.3.35*

The two common types of magnetic disks are floppy disks and hard disks.

(i) Floppy disks

The most common floppy disk now in use is the 3.5” disk. The assembly comprises a flexible disk protected by a plastic jacket or cover. The jacket/cover has an aperture, which allows the read/write head to retrieve or store data. 3.5” Floppy diskette is a removable, round flat piece of mylar plastic that stores data and programs as magnetized spots.

*Figure.3.36*
They can be used to transfer data from machine to machine. It requires a floppy disk drive. Typical diskettes hold 1.44 MB and have write-protection capability (like VHS tapes and audio cassette tapes).

5.25 inch disk

3.5 inch disk

Floppy disks has become obsolete

(ii) Hard Disks

It comprises at least one rigid disk protected by a strong, and usually air-tight, casing. The hard disk is usually a self contained unit containing many disks, read/write head, access arms and a motor enclosed within the casing, and the electronic circuit board controlling the disk operations attached to the external of the casing. Hard disc drives are made of thin but rigid metal or glass platters covered with a substance that allows data to be held in the form of magnetic spots. They are tightly sealed within an enclosed unit to prevent foreign matter e.g. dust, smoke and is usually the main auxiliary storage unit of a personal computer (often called the "C" drive)
It is faster than floppy and can hold thousands of Giga Bytes of data. Just like floppy disks, data is stored in tracks/sectors of a rotating disk.

(iii) Zip/Jazz drives (Hard disk cartridges or removable hard disks)
These consist of one or more platters enclosed along with read/write heads in a hard plastic case. A cartridge which is not much larger than a floppy disk may hold/stores as much as 2GB of data. They are faster than diskettes.

Tape drives: Magnetic tape is thin plastic tape that has been magnetically coated for storing data as magnetic spots. Tapes are used in magnetic tape units (reels) and in
cartridges. These are slower than disks). They are good for backups (cheap). Capacities can reach up to 6TB

Figure 3.40.

(b) Compact (Optical) Disk Storage

In this form of storage, a light source, usually laser is used to fetch data patterns onto the surface of the disk. Normally, two laser light sources are used; a weak laser is used to read data while a stronger laser is used to record data by burning pits under the surface of the disk.

Figure 3.41.

Two basic types of compact discs designed for use with computers are a CD-ROM and DVD-ROM.

(i) CD/ROM

CD-ROM stands for Compact Disk Read Only Memory. It is a non-erasable backing. A CD-ROM can hold up to 700 MB of data, instructions, and information, or about 450 times that which can be stored on a high-density 3.5-inch floppy disk. These come in different speeds (4X (600 KB/s), 8X (1.2 MB/s), 24X (3.6MB/s), 40X (6 MB/s), 52x ...). Some are read only, some write once, some re-writable. High-power laser beam is used to
represent data by burning tiny pits into the surface of a hard-plastic disk. To read data, a low-powered laser light scans the disk surface: Pitted areas are interpreted as a 1 bit. The optical disk technology used with computers consists of mainly: CDROM disks (texts, graphics and sound), CD-R disks, CD-RW disks. Most new software comes on CD's and so new computers often come with CDROM drive.

(ii) DVD (Digital Video Disks or Digital Versatile Disks):
A DVD-ROM (digital video disc-ROM) is an extremely high capacity compact disc capable of storing from 4.7 GB to 17 GB. DVD-ROM looks just like a CD-ROM but stores data, instructions, and information in a slightly different manner by making the disc denser by packing the pits closer together or using two layers of pits.

(C) OTHER TYPES OF MEMORY
Various types of memory are explained as under:

(i) Holographic Memory
This type of memory uses the principle of light to store data, instructions and information. Hence it is also described as optical memory. The data, instructions and or information stored are in terms of smear of dots on light sensitive plate. These memories are non-volatile and have got vast storage capacity.

(ii) Buffers
This is a special purpose temporary memory location, used during input/output (I/O) or processing to hold data and/or instructions temporarily between communicating elements.
Buffers are used to counterbalance the speed differences between the communicating elements, because buffers accept data instruction or information at the speed of the sending module/element and remit them at the speed of the receiving module. The CPU operates at a very high speed as compared to the speed of the peripherals; the buffer is therefore used to control the communication speed. If the buffer is used between the input unit and the CPU it is described as an input buffer. The input buffer accepts data and/or instructions at the speed of the input device speed, which is comparatively very low, and remits them at higher speed of the CPU to go as computer input. The buffer used between the CPU and the output unit is described as the output buffer, which accepts data, instructions or information at a high speed of the CPU and remits them at the low speed of the output devices, to go as computer output. The concept of using a buffer to control the speed of communication between computer modules is known as buffering.

3.5 **THE SYSTEM UNIT**

The system unit is made up of many smaller components; The CPU, the motherboard, the main memory (RAM and ROM), the auxiliary memory (Hard disk, floppy and CDROM drives), power supply unit and connecting cables.

**Motherboard**

![Motherboard Image](image)

*Figure 3.44.*

The motherboard holds everything together (CPU, memory, video card, I/O cards). They come in different kinds that vary in speed, quality, number of expansion slots, maximum memory
3.6 Case

The system unit is fitted into a case with all disk drives and a power supply. There are different types - desktop, tower, mini tower etc...

*Figure 3.45.*

*Here is a typical Personal Computer (PCs)*

*Figure 3.46.*
Here are some Mac computers (Mac G3 Cube, I-Mac, IBM Aptiva, macPro ...):

![Mac computers](image)

**REFERENCES**

2. Assorted websites
3. Mr Owira, Lecture notes (School of ICT, TUK)