UNIT 1 COMPUTERS AND THEIR COMPONENTS

Structure

1.0 OBJECTIVES

After the completion of this unit, you will be able to:

- learn the **basic functional organisation** of input and output devices within a computer system;
- understand the **symbiotic relationship between input and output,** especially in complex systems like Virtual Reality;
- **classify input devices** as either interactive or source data automation in order to more easily remember their similarities and differences;
- **classify output devices** as either hardcopy, softcopy, or action in order to more easily remember their similarities and differences; and
- **categorise** software into **System Software** and **Application Software** and identify the features of each of these categories.

1.1 INTRODUCTION

Computers have become omnipresent in every walk of life. Libraries are no exception. Before learning about how the computers are used in various activities of libraries, you should understand certain basic components of computers. A clear understanding of the concepts and technical terms is required so that you can appreciate the remaining units of this programme. In this unit you will be introduced to some of the basic concepts like hardware, software, etc. The unit starts by examining the basic configuration of a computer system, and then goes on to examine its components in detail. The basic configuration as described later is equally applicable to all types of computer system, whether we are considering mainframe, minicomputer or microcomputer systems. You will also learn a few facts relating to the history of computers.

1.2 CONCEPTS (PRELIMINARY DEFINITIONS)

Historically speaking the word computer has been derived from the Latin word "computere', which means to calculate. Therefore, the term computer can logically be applied to any calculating device. However, in technical parlance, the term has come to refer specifically an electronic computer. The following are the generally understood features of an electronic computer:

- It is an electronic device: Virtually all computers are "digital" because they are composed of digital (electronic) circuits built with microscopic transistors. Therefore, they can only process digital data (discrete electronic signals). Most "real world" data is "analog" (continuous electronic signals, e.g. light, sound, movement, etc.;) therefore, it must be converted to digital (A/D conversion) when encoded and vice versa (D/A conversion) when being decoded.

- Processing of data is performed electronically: A computer's circuitry is built from electronic "chips". The chips consist of integrated circuits (ICs) which are, in turn, made up of millions of "transistors". Transistors are, from a simplified viewpoint, electronically controlled on/off switches; therefore they can only store binary data (two states); humans call this basic data storage a bit (either a one or a zero). Data can have various forms including numeric , text, and multimedia (audio, visual, etc.), but all are "binary", i.e collections of bits. For example, "alphanumerics" (keyboard characters and numbers) each require at least one byte (a collection of eight bits) of storage.

- It has an internal storage: Computers have a mechanism to store data as well as programs. The stored program concept introduced by Von Neumann during the l940's states that programs and data are both stored in memory, i.e., that the program instructions and the data on which they operate "coexist" in the computer's primary memory

Based on the above features, we can define a computer as essentially an electronic device that can receive and store data and a set of instructions called programs. The computers act upon these programs in a pre-determined and predictable fashion to process the data in a desired manner.

The following words are so basic to computers that it is virtually impossible to talk about computers without using them. Therefore, we will give some preliminary definitions now and expand on them later when we cover these concepts in more detail.

- **"Computer":** an electronic machine that (a) processes computer data (digital) into human information (numeric, text, or physical) or (b) controls electrical devices.

- **"Microcomputer":** computer based on a microprocessor

- **"Computer System":** hardware, software, data, people, and procedures for using the system.

- **"Hardware":** physical equipment of a computer system.

- **"Software":** program that are "run" on the computer.

- **"Firmware":** software that is permanently stored in a computer's read only memory. **"Program":** set of step-by-step instructions, in a computer language, that causes a computer to execute a specific task in finite time.

1.3 THE INPUT-OUTPUT PROCESS

A computer systems accepts data as input, processes that data and provides data as output. During the processing the data must be stored. The processing is controlled by a sequence of instructions - the program - which is stored in the computer. The basic components of a computer system are therefore input devices, processor, backing storage devices and output devices. This fit together is as depicted in the following section as a schematic representation of a computer.

1.3.1 Schematic Representation

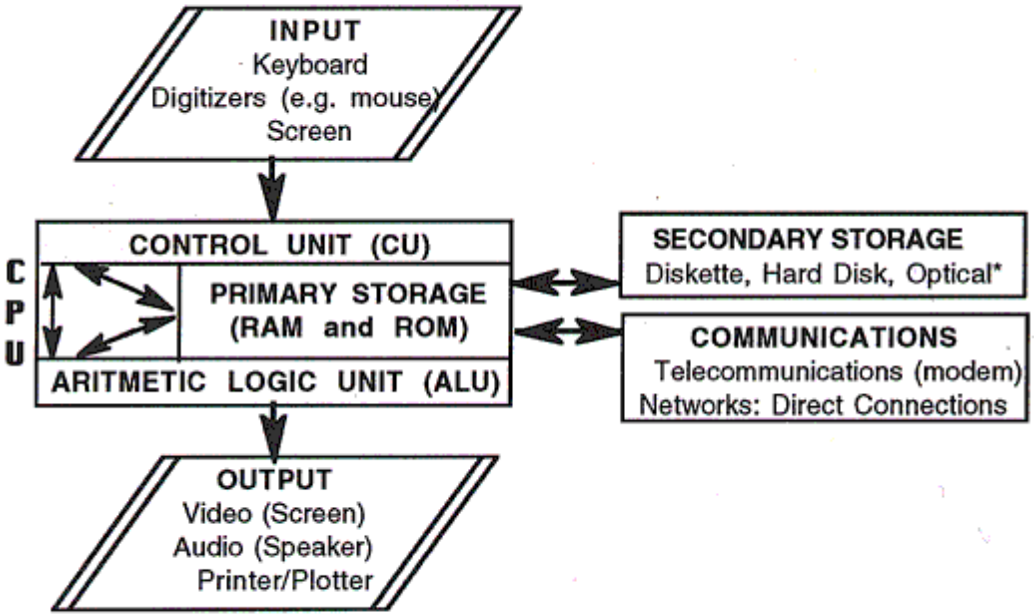


Fig. 1: Schematic representation of a computer system

Each of the components shown in the above diagram have unique contribution to make. These can be summerized as follows:

- **Input Devices:** Input devices accept data, convert data into machine-readable form and transmit data to the processor unit.

- **Central Processing Unit (CPU):** The Central Processing Unit, often called processor or just CPU, comprises a Control Unit, the Arithmetic and Logic Unit (ALU), and the Primary Memory. The arrows within the **CPU** simply dramatise the complex interaction of the two **conceptual components** of the CPU (**Control Unit (CU)**, and **Arithmetic/Logic Unit (ALU)**) and **Primary memory**; this schematic represent really reflects the organisation of a microcomputer, but is less true of large, multi-user computers like minicomputers and mainframes The functions of these sub-units are summarized below.

  The Control Unit: The **CU** is a conceptual representation of the microchip circuits that governs the operation of the CPU. It decodes and executes program instructions, and controls and coordinates data movements within the processor, and between the processor and other components of the computer systems.

  The Arithmetic and Logic Unit: The **ALU** is a conceptual representation

of the microchip circuits that (1) perform all the arithmetic calculations (such as +, -, % etc) and (2) makes the computer equivalent of logic decisions. (>,< <=etc.)

The Primary Memory: This unit stores programs during their execution, stores data that are being used by the current program, and stores the operating system which controls the operation of the computer system. Primary memory consists of Random Access Memory, RAM, where the users programs (and their data) must be stored in order to be run, and Read Only Memory, ROM, where permanent programs and data are built in by the manufacturer.

- **Secondary or backing Memory:** It maintains a permanent record of data and programs, maintains a store for the program and data being processed if the main memory cannot accommodate the data and program, and acts as an input/output device.
- **Output Devices:** Accept data from the processor, and convert data into the required output format.

You will learn more about each one of these components subsequently in this Unit.

1.3.2 Input Devices

People work with letters, numbers and words. Data is stored in a computer as binary digits (Bits), in other words data are represented inside the computer as a complex combinations of 0's and 1's (Zeroes and Ones). Input devices perform two basic functions. Firstly, they act as a means to enter the data and programs into a computer. Secondly, they are generally responsible for converting data into machine-compatible format.

Human Input Devices (Direct input devices)	
Keyboard	QWERTY keyboard
	Concept Keyboard
Pointing Devices	Touch Screen
	Light Pen
	Mouse
	Tracker ball
	Joystick
Video Input Devices	Digital cameras
	Digital Video cameras
	Analog image converters
Sound Input Devices	Voice Recognizer
Automated Input Devices (Indirect Input Devices)	
Graphic Capture	Image Scanners
Code Numbers	Bar Code Reader
	Magnetic Ink Character Recognition
	Magnetic Stripe Codes
	Smart Cards
Optical Input Methods	Optical Character Readers
	Optical Mark Readers

Input and Output devices are collectively called I/O devices. Input devices (and also output devices) are the hardware interfaces between the human user and computer system, but (as always) hardware is "driven" by software, so when we talk about an I/O device, remember there is an associated "device driver". Obviously the easier it is to get data into and out of a computer, the more useful the computer is. Both input and output devices can be sub-classified as either **direct** (to/from I/O devices) or **indirect** (to/from secondary storage, generally). For example, when recording loans transactions in a library circulation, the membership and the borrowed document information can be entered by the circulation assistant through a keyboard, then we are referring to a direct input device. On the other hand, same data can be entered through a barcode, then we call that device as an indirect input device. You may notice here that the appropriate selection of input method can have a significant impact on the accuracy, speed and effectiveness of data entry. The table below gives some of the popular Input Devices.

Let us learn more about these devices in the following sections. Let us concentrate more on those devices which are generally used by the libraries.

Keyboard

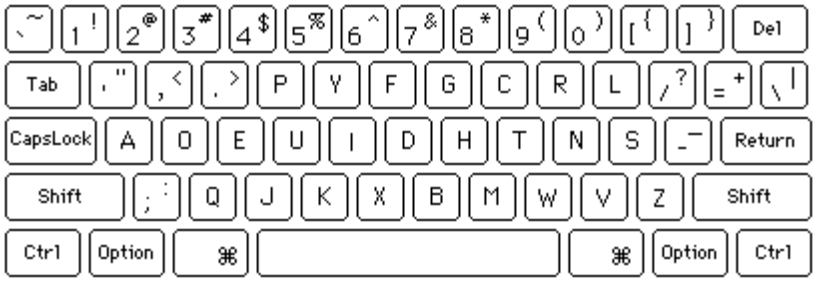
Keyboard is the most common data entry device. Almost all general-purpose computers are supplied with a keyboard. A keyboard has over 100 keys on it. When you press a key a number (code) is sent to the computer to tell it which key you have pressed. Keyboards are often used in conjunction with a screen on which the data entered are displayed.

The keys on a keyboard are usually arranged in the same order as those on a typewriter. This layout of keys is called **QWERTY** because Q-W-E-R-T-Y is the order in which the letters occur on the top row of the keyboard. Some newer designs have the letters arranged in a different order. Most people find the QWERTY arrangement best as they have had some practise using it, but some users trained on the new keyboards claim that they can type faster than the fastest typists can on QWERTY keyboards. The keys on the keyboard can be grouped into six groups. They are :

a) **Function Keys:** There will be 12 function keys labelled from F1 to F12. These are programmable keys used as shortcut keys to perform certain functions. Every software that you run responds differently to the function keys.

b) **QWERTY Keys:** These are the alphanumeric keys, which are arranged, in the same order that you find in a typewriter. These keys can be used to enter lower case as well as upper case alphabets. The Caps Lock and/or Shift key in combination with the alphabet key to enter the upper case alphabet. Space bar is used to leave space between words. You may remember here that a space is also equivalent to a character and treated like any other character. Thus, you should avoid unnecessary blanks in your data files.

Dvorak Keyboard Layout



c) **Special Purpose Keys**: TAB (Tabulation), CTRL (Control), ALT (Alter), ESC (Escape), Enter/Carriage Return , Backspace, Scroll Lock, Break, etc. are called special keys used for special purposes.

d) **Numeric Pad Keys:** These keys are used to enter numbers into the computers. They form a separate section in a keyboard called numeric pad. Experienced data entry operators use these keys quite fast to enter the numerical data.

e) **Cursor Control Keys:** These keys are used to navigate the cursor on the screen.

There are **no standard keyboard layout**; however typical keyboards have typewriter layouts (called "QWERTY"). The **Dvorak keyboard** was designed specifically to improve typing efficiency, but has yet to overcome the human's tendency to avoid "unnecessary" change! The layout of the Dvorak keyboard is given below. A **Concept keyboard** is a flat board which contains a grid of switches. Each switch can be programmed to do whatever you want. An **overlay** image is placed on top of the grid so that the user can tell what pressing on different areas of the keyboard (switches) will do. Concept keyboards are particularly useful for users such as children who would find using a QWERTY keyboard difficult and in locations where an ordinary keyboard might be damaged, e.g. by spillage or dust.

Keyboards are widely used because they provide flexible method of data entry and can be used in most applications. They do have limitations, however. Entry using keyboard is a slow form of data entry process and is prone to error. It may be costly.

Self Check Exercise

1) Draw a QWERTY keyboard lay out of your computer and identify different sections of it.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answars given at the end of this Unit.

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Pointing Devices

These are also called Cursor Control Devices. **Cursor Control Devices** are used to place the cursor (a highlighted screen location indicating where the next action will occur), select menu items, and control the computer by "clicking buttons" on the screen. If these are built into the computer they are called **integrated** pointing devices". There are a few such devices available. They are:

- **mouse**: a standard device of GUI (Graphical User Interface). New versions are **optical** and have no moving parts. An LED (Light Emitted Diode) records a reflected light which senses motion over a flat surface.

- **trackballs**: like an “upside-down mouse”; it has the advantage of being stationary.

- **joysticks**: a hand-held stick that pivots about one end indicating 360 degree directions.

- **trackpoint or pointing stick:** a miniature joystick that responds to the touch of a single finger.

- **trackpads**: a touch sensitive surface that translates finger motion into cursor motion.

Pen input devices

These are based on screens that sense the location of a special pen that is connected to the terminal. Following are some of the devices:

- **Light pens** either **detect the monitor’s light or emit light** that can be picked up by a specially designed monitor.

- **Styluses** are pens with electronic points heads which activate pixels on the monitor, usually a LCD display. **Handwriting recognition software** translates alphanumeric to digitised equivalents; normally these needs to be “trained” to recognise an individual’s carefully printed letters, numbers, and symbols. These have been rather primitive, but significant advances have been made recently. They are the primary input device of hand-held **PDAs** (Personal Digital Assistants) and **PIMs** (Personal Information Managers) State -of-the-art readers reportedly are very accurate.

- **Digitizing tablets** are similar to light pens or styluses except one draw on a tablet rather than the screen.

Touchscreen This allows selection of menu items displayed on a monitor by touching them.

Video Input Devices

- **Digital cameras:** Digital cameras have optics like regular photographic cameras; however, they record the single images electronically (rather than on photographic film) in digital form. These images are stored in the camera’s RAM (Random Access Memory), which like that in a computer is volatile). The images can be displayed immediately or stored on a secondary storage medium, e.g. a diskette, and processed, later, by image processing software.

- **Digital Video cameras:** These are digital cameras which can store sequences of digital images on magnetic tape and play them back as “movies”. They are similar to camcorders, but camcorders store their images as analogue data. Digital Video cameras are essential features of **videoconferencing** where remote computers can actually control a remote camera and remote users can share applications and collaborate on “**whiteboards**”.

- **Analogue image converters:** Photographs taken with regular cameras and videos recorded with camcorders store their images as analogue data. There are special kinds of hardware that can take these images (scanning photographs or converting camcorder tapes) and convert them to digital images which, like any other digital image, can be processed by computers.

Audio Input Devices

A) **Digitized Audio Signals:**

a) Audio (analogue) signals can be converted to digital signals by **analogue to digital converters**, processed by a computer and converted back with digital to analog converters. This allows computer manipulation of music (See MIDI, below), speech or any recordable sounds.

b) **Synthetic audio** signals can be created by the computer.

c) Musical Instrument Digital Interface (**MIDI**) devices allow the input and output to any musical instrument capable of electrical I/O. The music, once digitized in the computer's memory can be processed by musical software giving an incredible opportunities for creativity and innovation.

B) **Voice Input and Speech recognition:**

a) Microphones convert spoken words (analog signals) to digital signals that can be processed by a computer. (**Words are "digitized"**.)

b) Digitized words are compared to "**voice templates**" stored in memory.

i) Customizable devices can be "trained" to recognize an individual's speech.

ii) Current systems are still rather primitive and have limited vocabularies; however, rapid improvements are being reported.

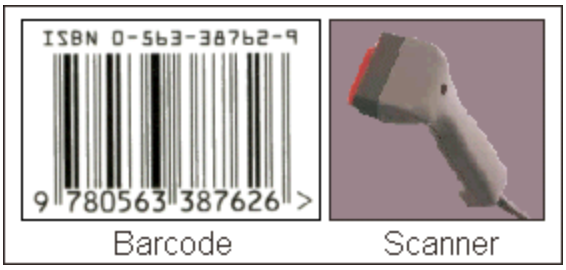
c) If a word is recognized it is processed; if not then the user has to ask for recognizable input.

Graphic Capture

Image Scanners are popular examples of graphic capture devices. This i s one of the extensively used input devices in libraries where digital library projects exists. When a page of text already exists, like the page that you are reading now, it can be directly input into a computer using a scanner. Scanner can be used to input not only the texts, but the photographs, drawings, etc. Image Scanners (Gray-scale or colour) **digitize** the pictures (which are analog data). The resulting **bitmapped images** (Each pixel has a collection of bits that define its colour) can be easily modified by graphics programs. The resolution of bitmapped images is measured in **dpi** (dots per inch).

Code Numbers

- **Barcode readers:** Barcodes are widely used in retail outlets and libraries. Each barcode represents a number. You can see the barcodes of ISBN on books. The bar code is a pattern of thick and thin bars divided by thick and thin spaces. Only the relative separations and thickness of the bars are important. Barcodes can be printed in different sizes and colours. The barcode is read either by passing a light-pen over it or by passing the bar code over a flatbed scanner. Barcodes are suitable for data input when all that is necessary is to identify an item, and the data input simply comprises a code. The reading of the barcode records a transaction, and information is fed back to a computer database. Barcode systems are easy to operate and have very low error rates. Occasionally, a scanner can read a barcode number incorrectly. A check digit is included in the barcode number to reduce the likelihood of this happening.



Barcodes are helpful in libraries for acquisitions, circulation, serials control and stock-verification works.

- **Magnetic Ink Character Recognition (MICR):** This input device is widely used by banks to process the tremendous volume of checks being received by them. You can observe at the bottom of a cheque leaf some code numbers which are written using a special ink that contains magnetisable particles of iron oxide.

- **A magnetic stripe code:** It is a short length of magnetic tape which may be stuck on the surface of a tag, card or document. On plastic cards such as credit cards, the stripe is usually sealed in. Stripes store data in the form of magnetic spots which represent the 1's and 0's of the ASCII code.

- **Smart Cards:** These have a memory store in the form of a very thin integrated circuit sealed into them. These can be used to store data about a customer which can be updated as transactions are made using the card.

Optical Input Methods

- **Optical Character Readers (OCR):** This device is similar in concept to MICR. Characters in a special font are printed on a document, and the reader scans the document for reflected light patterns, then translates those patterns into a pattern of electrical signals which are passed to the computer store. OCR-A (American Standard) and OCR-B (European standard) are examples of standard fonts. Characters that cannot be recognised are rejected.

- **Optical Mark Readers (OMR):** These are similar to OCR except that the reader recognizes marks in appropriately positioned boxes rather than characters. These found applications in areas where responses are one out of a small number of alternatives and the volume of data to be processed is large. One can notice the usage of this in Bank examinations.

Self Check Exercise

2) Explain why a bar code reader is a good data input device in stock-verification work of a library.

Note: i) Write your answer in the space given below.

ii) Compare your answer with the answers given at the end of this Unit.

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1.3.3 Output Devices

Output devices are the means by which computer systems communicate with people. The convenience of use of these devices and the quality of their results has a significant impact on the effectiveness of computer systems. Output devices accept data from the processor and convert them into the required output format. In other words, output devices translate the data in the processor into a format that is suitable for people to use.

Most "real world" data is analogue, i.e. it consists of *continuous signals* like sounds, pictures, voltage, etc. However, computers can only process digital data (*discrete signals*); therefore, input usually involves analogue to digital conversion (A/D hardware) and output reverses the process using D/A converters.

Output can be sub-classified as either **direct** (to/from I/O devices) or **indirect** (to/from secondary storage). Output can also be divided into another two kinds: **hard copy** output (paper, microfilm, etc.) provides a permanent record while **soft copy** output (visual, audio, tactile, or action) is transient. **Action output** facilitates control of electromechanical devices, e.g. **robotics**. For the sake of convenience, let us follow the latter classification to discuss the output devices in this Unit.

Visual Output Devices (Soft copy)

- Cathode Ray Tube Displays (CRTs): These are the most commonly seen output device. The computer screen that you see in a computer is made of CRTs. They are also called monitors or visual display terminals (VDTs). Monitors look identical to a television screen. They produce fast and virtually costless output of information.

CRTs use faster scan technology to portray images as bitmapped graphics on a phosphorescent screen. Electrons are fired at the screen and light up tiny dots of phosphor, which then glow for a short period of time. (See the CRT figure given below). Each point is called a picture element or pixel. Since the phosphors glow momentarily, the electronic gun keeps on firing the electron beam at regular intervals. This refreshing mechanism is measured in Hertz (Hz) or cycles per second. A low refresh rate leads to screen flicker.

Monochrome monitors use one colour images (usually black) on a one colour background (usually white), e.g. old mainframe monitors. These are now virtually obsolete in PCs. On the other hand colour monitors use a triad of red, green, and blue phosphor dots which are stimulated in varying degrees to produce a wide range of colours. Composite video monitors (like TVs) have one electron gun.

However, composite video has lower resolutions than RGB monitors. RGB monitors use three electron beams which give a higher resolution display. Virtually all modern monitors are RGB.

The quality of the screen display, or its resolution depends on the number of pixels on the screen. Resolution indicates the ability to show detail; the more pixels per inch the higher the resolution. There are several standards for IBM/ Clone monitors including:

i) CGA (Colour Graphics Adapter) 320×200 pixels 4 colours

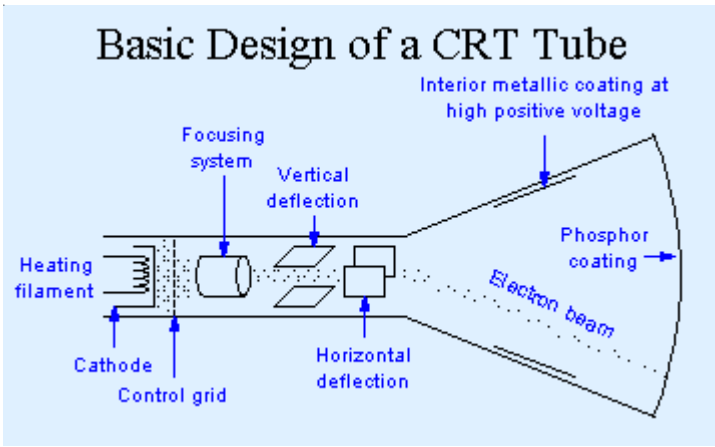
ii) VGA (Video Graphics Array) 640×480 pixels (or 256 colours at 320×200)

iii) Super VGA 800×600 pixels (min.) 256 colours

iv) XGA (Extended Graphics Array) 1024×768 pixels (max.) 256 - 64K colours

v) High-end monitors: 1280×1024pixels, 1600×1200pixels, and 1800×1440 pixels.

Bitmapped CRTs allow individual pixels to be addressed thereby producing greater screen control; this is the origin of WYSIWYG (What You See Is What You Get) applications that can incorporate high resolution graphics (e.g. all modern PC monitors). On the other hand old fashioned **character-addressable CRTs** only address or manipulate groups of pixels (that form alphanumeric) and are inherently non-WYSIWYG and have crude graphics (e.g. mainframe and minicomputer monitors). **Vector Graphics** screens create images by the electron gun tracing between specified points on the screen rather than scanning every row; they are limited to special types of graphics monitors.



You should be familiar with some of the terminology used in describing features of CRTs. Let us just list them here. Try to collect more information on them. **Paging** is the movement of the screen image one screen at a time. **Scrolling** is the movement of the screen image one line at a time. **Windowing** allows different outputs to be displayed on different parts of the screen. **Aspect Ratio** corresponds to the ratio to describe the resolution mode. **Refresh Rate** is the frequency at which an electron beam sweeps horizontally across the screen sequentially stimulating phosphorescent pixels (screen picture elements) and it is measured in Hz (Hertz) or Cycles Per Second.

l Flat Panel Display: First introduced in watches and clocks in 1970s, this technology is now applied to display terminals. They eliminate flicker and radiation and minimise size problems of CRTs. Further, they are popular for their low energy consumption. However, the quality of the images is relatively

poor. Hence, they are commonly used in portable devices because of compactness and low energy requirements.

The most popular type is the **Liquid Crystal Display (LCD)** which has a thin layer of liquid crystal molecules, divided into small squares forming pixels, that are held by two glass sheets. When power is applied to a square it turns opaque. LCDs used to be limited in size, brightness and clarity, but current technology has significantly improved. **Gas-plasma** display give the best image (but low contrast) but can not be battery operated.

- Project Displays: The small sized screen of the displays discussed above is not suitable for a group presentation. Project displays provides an enlarged image and could be projected on a large screen. These systems can be connected directly to the processor and the output will be displayed on the large screens.

Audio Output Devices (Soft copy)

The audio output device convert the digital signals and give the output in an audible format. Speech synthesizers transform digital computer signals into voice output. The voice maybe choppy and unnatural, but it is easily understood. Audio output units have a varied application. One of the applications that all of you might have experienced is the recorded voice response in a telephone system or railway/airline reservation systems.

Speech synthesisers use different methods of output. In the **word analysis method** entire digitised words from the computer's vocabulary are combined, under computer control, into digitised sentences and then converted to analogue output. This requires a huge amount of memory. In the **constructive synthesis method** the basic elements of speech, called "phonemes" (only 40 in the English language) to construct speech output governed by timing, pitch and inflection controls. This has minimal memory requirements.

Hardcopy (print and film) Devices

Printers and Plotters

- Printers: They are used to print the output data on paper. Such output is referred to as printout or hard copy. Printers can be classified based on various characteristics. They are:

  A) Image **formation** (measured in dpi (dots per inch):

     a) **Full character** alphanumeric (no graphics) each have a separate symbol on a ball, daisy wheels, thimble, band, belt or chain mechanism.

     b) **Dot-matrix** alphanumeric and graphics are formed by patterns of dots from a single print head.

     c) **Raster scan images** (alphanumeric/graphics), e.g. laser printers, are like copiers.

  B) Image transfer:

     a) **Impact** printers transfer images by the print head striking a ribbon like a typewriter.

     b) **Non-impact** printers transfer images by **heat** (electro-thermal and

thermal-transfer printers), **electrostatic charge** (laser printers), or by "**drawing**" with ink jets.

C) Number of characters printed at one time, measured in ppm (pages per minute):

a) **Serial** (bi-directional) printers print one alphanumeric or graphics pixel at a time.

b) **Chain printers** transfer one line of alphanumeric or pixels at a time.

c) **Page printers** (laser printers) utilise a combination of raster scan and xerographic technologies to produce one whole page at a time.

- Plotters: Though a few printers listed above are capable of producing graphics, there are a few special plotters exclusively to print a good quality drawing and graphs. There are two types of plotters. **Flatbed** plotters have a drawing instrument (pen, ink-jet, electrostatic head, or heater element) that moves both horizontally and vertically, under the control of input voltages, over a flat piece of stationary paper. **Drum** plotters have a drawing pen that move vertically while the paper, on a drum, rotates under it.

Computer Output Microfilms (COM)

Special computers can produce their output directly onto microfilm. In this way, vast amounts of data in human readable form can be stored in a very small space without the need of large quantities of paper. This form of output has applications in libraries, book shops and in situations where large amounts of text and pictures need to be sent through the post. The microfilm is read by using a special device which magnifies the text and pictures so that they can be seen by eye. This expensive medium will probably be replaced by laser disks.

Action output: computer control of electrical devices

Tedious, error prone, and dangerous jobs are ideal for computer automation. Computer cause some mechanical movements required to do specific tasks. Automated data acquisition can free laboratory workers from tedious tasks. Robotics is a field of computer science which deals with action output. Robots are mechanical devices, controlled by computers, that can move and/or do work**.** (NOTE: They rarely resemble humans except in the movies and on TV!). The simplest robots only do work under program control. The most complex robots have sensors that allow them to see, hear, and feel and to respond to the feedback from these sensors. Computer vision is an active field of research that is still far from the capability of the human eye. Rigorous research is on to improve the action output.

1.3.4 Central Processing Unit

The processor of a computer is a very complex VLSI (Very Large Scale Integration) circuit. However, from an over simplistic illustrative viewpoint it can be thought of as a collection of processing and storage units within a Arithmetic Logic Unit (ALU) and Control Unit (CU) that are linked internally and externally by busses which carry binary signals between. (Refer figure given under the section 1.3.1 of this unit). Higher the bandwidth or processing speed of CPU the faster the machine is. Today's processors speed comes in the range of GHz (Giga Hertz).

Arithmetic Logic Unit (ALU)

The Arithmetic Logic Unit (ALU), as the name indicates, performs all the arithmetic and logic operation. ALU (greatly oversimplified for illustrative purposes) consists of:

a) **accumulator,** the main data register where all the intermediate results of a calculation are kept ("accumulated") until the final result is determined (which is then stored in memory);

b) **data registers** are supplemental storage registers that support the operations of the accumulator;

c) **computational circuits** (e.g. a binary adder) that performs **mathematical operations**; and

d) **operational circuits** that perform **logic operations**

All **math operations** are performed in binary numbers and all **logic operations** are performed using binary operations. Math operations include addition, subtraction, multiplication and division. Logical operations allow programs to contain repetition and selection, the two essential control structures of programming. Logical operations performed by ALU include comparing two quantities; keeping a counter and deciding the further route.

Control Unit (CU)

This unit controls the internal functioning of the computer and input/output units. The role of control unit in CPU is that of a "manager" or "a traffic cop". In other words, it controls and co-ordinates all hardware operations. The components of CU (greatly oversimplified for illustrative purposes) are:

a) **decoders** which interpret program instructions (object code written in machine language),

b) a **timer (or clock)** which sequences all CPU activities,

c) **logical gates and circuits** which distribute signals which activate various components of the CPU,

d) **program counter/register** which keeps track of the next instruction to execute, and

e) **registers** (e.g. instruction, address, etc).

Primary CU **Functions** (in addition to those discussed above) are listed below. It

a) **reads and interprets** machine language instructions;

b) **controls the transmission of data** between ALU, registers, cashes, primary memory, and auxiliary memory;

c) **controls the sequence of execution** of program instruction (i.e. governs branching, jumping around within a program) which allows repetition and selection.; and

d) **directs ALU** as to what math or logic operations to perform.

Primary Memory

Primary memory, also called main memory or internal memory, provides temporary storage of programs in execution and the data being processed. It is known as immediate access storage (IAS) as this is the portion of CPU which can be accessible directly. From a hardware point of view the primary memory is formed by a large number of basic units referred to as "memory cells" Each memory cell is a device or an electronic circuit that has two or more stable states, which represents the binary numbers 0 (Zero) or 1 (One). The computer can retrieve any item of data or any instruction stored in primary memory at lightning speed. The modern computer does this in a few nano seconds.

Primary memory can be further grouped into Random Access Memory (RAM) and Read Only Memory (ROM). **Cache** memory (small, fast RAM) is designed to hold frequently used data. Let us summarise the features of each of these below.

- **Random Access Memory (RAM) :** This memory allows writing as well as reading of data unlike ROM which does not allow writing of data on to it. It is a volatile storage because the contents of RAM are lost when the power (computer) is turned off. If you want to store the data for later use, you have to transfer all the contents to a secondary storage device. There are several types of RAM, the most popular of which include:

  i) **DRAM**, dynamic RAM, although its name sounds sophisticated, is the oldest and simplest (and therefore the slowest) type of RAM used today. The word "dynamic" comes from the fact that it must be electronically "refreshed" constantly in order to maintain the data it stores.

  ii) **SRAM**, static RAM, unlike DRAM, does not need to be refreshed; its storage is fixed (as long as power is supplied to the computer). This newer, more dependable type of RAM is faster, but more expensive than DRAM. SRAM is often used for cache memory;

  iii) **EDO RAM**, enhanced data output DRAM, is a type of RAM that improves the memory access time on faster microprocessors such as the Intel Pentium. EDO RAM was initially optimized for the 66 MHz Pentium.

  iv) **SDRAM, synchronous DRAM**, is a new form of RAM that can be synchronized to the clock speed of the computer, a powerful feature that optimizes data access by the system buses.

  v) **RDRAM**, Rambus DRAM, is Intel's designated successor to SDRAM has an effective speed of 800 MHz and a peak data transfer rate of 1.6 GBps. However, it has yet to prove itself, and there are several rivals, e.g. **DDR SDRAM**, that are slower but have 64b bus widths thus providing comperable transfer rates.

- **Read Only Memory (ROM):** Another type of microcomputer memory is read only memory. Data is 'burnt' into the ROM chip at the manufacturing time. Unlike RAM, the data on the ROM is non-volatile, ie., data is not lost when the computer is switched off. Following are the popular ROMs.

  i) **PROM** (Programmable ROM) can be programmed to record information using a facility known as a PROM-programmer. Once the chip has been programmed the recorded information cannot be changed.

  ii) **EPROM** (erasable PROM) is erased by shining ultraviolet light on the

exposed chip. **To write to or erase from EPROM**, one must use a PROM burner.

iii) **EEPROM** (electronically erasable PROM) is more convenient than EPROM because it can be erased electronically and can be written to in bytes.

iv) **Flash memory**, a special type of EEPROM, can be erased and rewritten in multi-byte blocks rather than the single bytes characteristic of EEPROM. Flash memory is most often used to hold control code such as the Basic Input/Output System (BIOS) in a personal computer; these are often called "flash BIOS".

- **Cache memory (small, fast RAM):** It is designed to hold frequently used data. In general, **Cache** (high speed RAM that is configured to hold the most frequently used data) is used to improve system performance. **Memory cache** or **CPU cache** is a dedicated bank of high-speed RAM chips used to cache data from primary memory. When data is read from primary memory, a larger block than is immediately necessary is stored in the cache under the assumption that the next data needed by a program will be located near the data being read; when that data is needed, it will then be waiting in the high-speed cache. Memory Cache may be either built into the CPU (level 1 , or **L1**, cache, e.g. Pentiums and PowerPCs) or contained in separate chips (level 2, or **L2**, cache,).

Self Check Exercise

3) Describe the basic components of a modern computer system and explain their role in its working.

4) Distinguish RAM and ROM.

Note: i) Write your answer in the space given below.

ii) Compare your answer with the answers given at the end of this Unit.

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1.4 SOFTWARE

Computers are general-purpose machines that could potentially perform a whole range of tasks, from recording issues of books, manipulating management statistics, keeping a record of expenditure, to maintaining personnel record. For computer to perform the specific tasks required of it at specific times, it is necessary to provide instructions to the computer. These instructions, which indicate which tasks are to be performed, are known as programs. Software is a general term that refers to computer programs which are collectively stored on secondary storage media. **System Software** refers to a program which drives the computer. It manages and renews resources of the system except for memory, I/O, CPU & file system. This presentation ends with a concise summary of **Application Software** which is prerequisite to our study of Word Processing and Desktop Publishing, Graphics, Electronic Spreadsheets, Database Management, and Telecommunications, and Integrated Applications which will be the focus of the

laboratory sessions where the exercises associated with these concepts are to be performed. You will learn more about the software in subsequent Units. Here, we shall just list major categories of software along with their features.

1.4.1 System Software

It is designed to act as an **interface between users or their application programs and the computer system itself.** System software has three basic categories: system management (which includes the operating system (O.S.), the foundation of system software), system support, and system development.

System Management:

A) The **BIOS** (Basic Input Output System) is the most fundamental software of a computer system. It is the **firmware** that "**boots**" your computer, i.e. that gets your computer started when you turn it on. (This feature is the basis of the BIOS being called a **"bootstrap" program**, particularly in older computer terminology.) It checks your system hardware, loads the operating system and file system from secondary storage into RAM, executes the operating system and then turns control of the system over to the operating system. For example on a PC, the BIOS is responsible for the scrolling data displayed about your computer system, before Windows screen appears. (On a Mac the BIOS is simply called the "firmware".)

   a) The BIOS also assists the operating system by governing the flow of data to and from peripheral devices, thus acting as an interface between input/output devices and the operating system.

   b) The BIOS typically is provided on **EEPROM** (electrically erasable programmable read only memory. This makes it possible to upgrade your system BIOS by "**flashing your BIOS**", i.e. writing a new program to the firmware.

B) The **Operating System** facilitates the (1) user's and/or (2) program's access to the computing system. Within the O.S., the **Supervisor** program **governs** computer operations, **coordinates** activities within the computer system, and **controls** system resources. In general the O.S. has three primary management functions:

   a) **Job management** (allocation and scheduling of the CPU): A single CPU can process only one program at a time; however, a CPU can be **shared** by giving sections of CPU time to different programs in a specified sequence.

      i) Processing may be interrupted by an **event** (e.g. the access of an I/O device) or by reaching the end of a **time slice** (a specified length of CPU time). The interrupt signals the execution of another application, which normally will be the continuation of one that was previously interrupted. Because the processor is executing millions of instructions per second it appears to users to actually be running the applications simultaneously.

      ii) **Scheduling schemes** govern the sequencing of programs. The simplest is the **first-come-first-served** scheme; a **priority scheme** gives CPU time according to the importance of the user or program.

   b) **Resource management** (allocation and scheduling of peripheral devices)**:**

i) The method of allocation varies according to the type of device. Transfer of data to/from a device is controlled by its **device driver**, a program that controls a particular type of hardware device. A device driver could be viewed as a "**software interface**" between the computer and the device (as opposed to the physical connection which would be its "hardware interface"). Device drivers now come bundled with operating systems, particularly for PCs which boast of "plug and play" peripheral additions.(However, if you purchase a new device, for which the operating system has no embedded driver, you will have to install the new device driver.) A device driver essentially converts the general input/output instructions, from the BIOS of the operating system to instructions that the specific device can execute.

ii) Peripheral devices are allocated by the O.S. in response to the requests or requirements of the programming being run. **Sequential access devices** (e.g. tape drives) may be assigned for the program duration, but **direct access** (e.g. disk drives) devices can be assigned and released as needed.

iii) **Spooling**, which allows I/O to be stored on disk until needed, frees the computer for other tasks and allows more efficient usage of I/O devices. For example, output can be spooled to a "printer server" and the user can continue to use his or her computer while the printing waits until a printer is available.

c) **Data management** (allocation/scheduling of memory, both RAM and Secondary Storage):

i) There are numerous O.S. **strategies for sharing** of RAM or secondary storage (which is essential to the efficiency of multitasking or multi-user systems).

ii) **Basic Input/Output System (BIOS)**: converts keyboard characters to computer code and reverses this process to output to a secondary storage device or output device.

iii) **Virtual memory** O.S. allows a computer with limited RAM to be "fooled into thinking that its memory is larger" by replacing the part of a program that is in RAM (when it is finished executing) with the subsequent part which is on disk storage; this process can be repeated until all parts of the program are "rotated" through RAM. The entire program only resides on disk; its parts are sequentially switched into RAM, executed, and then replaced.

System Support (for the user):

A) **Service Programs** facilitate the use of the computer system in an **efficient** and **user-friendly** way.

a) Graphical User Interface (GUI)are designed to provide an **intuitive access to O.S. commands**, via windows and dialog boxes, thus avoiding the need to memorise the commands or their syntax (grammar) .

b) **Utilities** are programs that perform repetitive, routine tasks on their own. For example, the **Bootstrap** program, which is permanently stored in the computer loads the disk O.S. when the computer is switched.

c) **Device drivers** are programs written by the manufacturer of peripheral devices; these programs allow their device to be connected to a specific make of computer.

B) System **Monitors** keep a running record of:

a) **system usage** (job accounting, priority enforcement, etc.)

b) the **performance** of programs and system hardware. Performance can be effected by selecting CPU scheduling schemes, changing priorities, adding more or faster resources, and alleviating bottlenecks.

c) the **security** of the system and the individual user's files.

C) **System Maintenance:**

a) **Fault-tolerance** capabilities allow computers to auto-matically overcome system problems that arise; this requires **multiprocessing capability**.

b) The O.S. can prompt the user when it needs input in order to continue executing. It sends **error or warning messages** to the user in case of program termination or malfunction of some component of the computer system. Sometimes the user can intervene in the O.S. to overcome the problem.

c) If a program **crashes**, or **use too much time** (e.g. infinite loop) or memory, etc. the O.S. terminates its execution.

System Development (for developing software or writing programs):

A) **Language Translators** are software that translate programs written in computer language (**source code**) into machine language (**object code**)

a) **assemblers** translate a **complete assembly language** program into object code; Each microprocessor has its own assembly language code.

b) **compilers** translate a **complete high level language** program into object code; For example C-compiler, C++ compiler

c) **interpreters** translate **individual instructions** of a **high level language** and **executes them immediately;** this allows greater interaction with the computer while programming but programs run slower than those from assemblers and compilers

B) **Application Development Systems** and **System Development Programs** assist the programmer in developing and coding software, for example:

a) an **editor** allows the programmer to create, edit, or modify programs or data;

b) a **debugger** facilitates the isolation and elimination of program errors;

c) **CASE** (Computer Assisted Software Engineering) packages, a hot topic in software development circles, actually generate programs from general user specifications.

1.4.2 Application Software

Application programs are written individually to operate specific tailor-made

procedures and systems, such as sales ledger systems, wages systems, library circulation control systems, word-processing systems etc. Some applications programs are available in the commercial marketplace as packages or software packages. **Application software** includes programs that turn the computer (a general purpose tool) into a **special purpose** tool. These include:

a) **general productivity** software like word processors, electronic spreadsheets, database management systems, graphics packages, etc.

b) **education/entertainment** software like tutorials, training programs, games, etc., and

c) **professional** software for use in business, science, medicine, libraries etc.,

1.5 CLASSIFICATION OF COMPUTERS

People classify computers differently based on various characteristics. Let us study them briefly.

- Classification based on working principle: This classification yields three different types of computers, viz., analogue, digital and hybrid. **Analogue computer** does not compute directly with numbers; rather it measures, continuous physical magnitudes (e.g., pressure, temperature, voltage, speed, etc.) which represent or are analogous to the numbers under consideration. Slide rule, thermometers are often cited as examples of analogue computers. **Digital computer**, on the other hand, operates by counting numbers. They represent data in discrete form. They convert all inputs into numbers before processing them. These types of computers are more accurate than the analogue computers since there is no analogous representation. All modern electronic computers are examples of digital computers. The third category, **hybrid computers**, combines analogue and digital capabilities. Hybrid computers are used for some special application.

- Classification based on memory size and processing power: This classification yields four groups of computers. They are Microcomputers, mini computers, mainframe computers, and super computers. Due to the tremendous developments in the technology, the distinctions between these categories are increasingly becoming blurred. **Microcomputers** are the most popular and widely used computers.

- As the CPU is a single microprocessor, this category of computers is called microcomputers. The two dominant microprocessor families are the x86 processors manufactured by Intel, AMD, and Cyrix and the PowerPC processors manufactured by Motorola. (See the table above.) The different family members differ in architecture (word size, data bus size, address bus size, etc.). However, each different architecture, e.g. the Motorola G4, AMD Athlon, or the Intel Pentium III, can have several “versions” differing in clock speed; generally, if the clock speed of a processor is doubled its speed is doubled. **Minicomputer,** a term originated in 1960s but fast becoming obsolete in computer parlance, have lesser power and costs less than a mainframe computers. They are often dedicated to a particular purpose such as database access and support several users at a time. **Mainframe computers** are large and powerful machines. They usually support many users with varied applications. They can process large quantum’s of data at greater speeds. The mainframes are multi-user and multi-tasking and therefore support large network of terminals and remote job entry stations. Generally, they play the role of a central machine of very large organizations. **Super computers** are the upper end of the state-of-the-art of computer technology. They are super in more than one ways.

x86 PROCESSORS (from Intel)							
	CPU	Clock Speed (MHz)	Bus Size (bits)	Max RAM MB	Floppy Disk	Typical Hard disk	Operating Systems
16-bit CPUs	8088 8086	5 5-10	8 16	1	5.25" 360K	10-20MB	DOS DR DOS
	286	6-12	16	16	5.25" 1.2MB	20-80MB	DOS DR DOS Windows 3.0 OS/2 1.x
32-bit CPUs	386DX 386SX 386SL	16-40 16-33 20-25	32	Max RAM GB 4	5.25" 1.2MB 3.5" 1.44MB	60-200MB	DOS DR DOS OS/2 1.x OS/2 2.x Win 3.x Win 95 Win 98 Win NT Win 2000 UNIX (SCO) Solaris Linux Misc. DOS multiuser
	486DX 486SX	25-100 20-40	32	4		200-500MB	
	Pentium	60-200	64	4		500MB-40GB	
	Pentium MMX	150-233		4			
	Pentium Pro	150-200		64			
	Pentium II	233-450		4			
	Pentium III	450-1GHz		4			
	Celeron	266-500		4			
	Xeon	400-850		64			

They are fastest, probably the largest, and most expensive computers. They can process at very great speed like one trillion instructions per second. There are a number of manufacturers who are in the market of manufacturing supercomputers. Some of them include CORAY[1] (CRAY IM, CRAY X-MP, CRAY2, CRAY3), CDC (ETA-10, ETA 20), Fujitsu (VP-200, VP-400), Hitachi (S-810/20), NEC (SX-2), etc. India's Centre for Development of Advanced Computing (C-DAC) has produced a supercomputer called PARAM.

- Classification of computers based on their generation: This is the most popular method of categorising the computers. The study of the generation gives a good idea about the evolution of computers over the years. The following table provides you a clear picture of the capabilities and technology involved in various generations of computers.

- There are different types classification of parallel computers which contains more than one CPU and these machines are also called parallel computers. If memory is shared by all CPU's, then it is called highly completed system. If memory is distributed that is each processor contain its own memory and not dependent up a common memory module, it is called loosely completed or disrupted system.

GENERATIONS OF COMPUTERS

	FIRST (early 50's)	SECOND (late 50's)	THIRD (60's)	FOURTH (70's +)
Circuit technlogy:	**vacuum tubes**	**transistors**	**Integrated circuits**	**microchips (LSI)**
Relative speed:	1	100	100	1,000,000 +++
Relative cost:	1	0.1	0.01	0.001 —-
RAM capacity (bytes):	1,000-8,000	4,000-64,000	32,000-4,000,000	>>32,000,000
External storage:	cards	tape	magnetic disks	mass storage
Operating System:	Single user; jobs scheduled manually	Single user; jobs scheduled automatically	Multiple users; time-sharing	Multiple users; distibuted systems

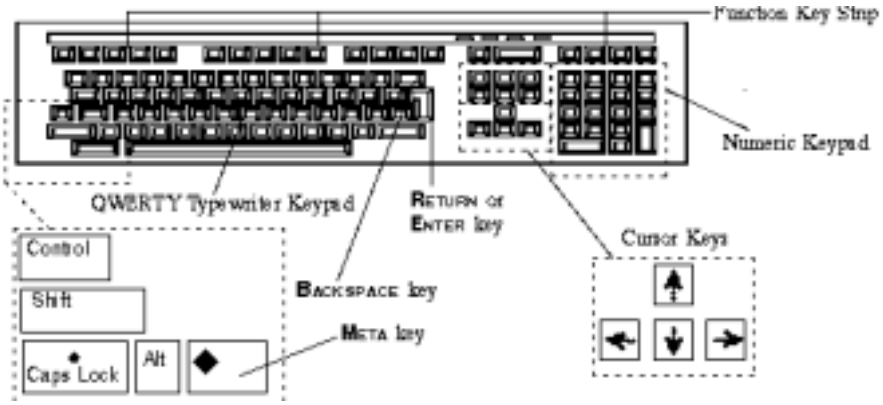
[1] Note: The supercomputers manufactured by these companies are given in the brackets

1.6 SUMMARY

In this Unit you have learnt some basic concepts concerning computer systems. The concepts that you have learnt are computers, microcomputers, computer system, hardware, software, firmware, and program. The Input-Process-Output schematic diagram is used throughout this course as the basic format on which all software and hardware are organised. You have noticed that the basic computer configuration comprises the central processing unit, input devices, output devices and storage devices. The central processing unit comprises an arithmetic and logic unit, a control unit and the primary memory. Input devices are used to enter data into the computer. Output devices such as monitors and printers allow information to be output from the system. Primary memory helps to store data and programmes required by the computer. As it is volatile in nature, we require a more permanent means of storing data. Secondary storage devices help in this regard. Instructions to the computers are given through programs/ software. Software is generally classified into two categories: a) system software allows the user to manage a computer system, provides support, and facilitates software development; and b) application software consists of programs that turn a general purpose computer into a special purpose tool, e.g. word processor, web browser, game, etc.

1.7 ANSWERS TO SELF CHECK EXERCISES

1) The most widely used keyboard type is the QWERTY. The keyboard lay out is given below:



2) Barcodes are very efficient in stock-verification work of a library because of the following reasons:

   - Large amount of data can be input/gathered in short-period.
   - Barcode readers have very low error tolerance. Hence the accuracy of data gathered is very high.
   - Collecting of stock-verification data could be carried out near the stock itself.
   - Even non-professionals could be assigned the job of collecting data through barcode readers.

3) The basic components of a computer system are: i) input devices, ii) the central processing unit (CPU), and iii) the output devices. An input device is a peripheral, which accepts data and sends it to the CPU. Data presented to an input device has to be in the right form for the device, e.g. a barcode reader will only read barcodes. The input device converts the data into the computer's own internal code before sending it to the CPU. The CPU is the physical devise that controls computer operations. It consists of three components, viz., the control unit - which co-ordinates various works; the ALU - which performs arithmetic and logical functions; and the primary memory - which stores the data and programs required by the computer for the task being carried out. Output devices usually receive data from the CPU and change it into a form which can be understood by humans. However, in some cases (for example when the computer is used to control another device), the output may be in a form which is suitable for passing instructions to another device controlled by the computer.

4) RAM (Random Access Memory) allows for Read and Write operations. ROM (Read Only Memory, as the name indicates, allows only Read operation. While RAM is a volatile memory (i.e., the contents get erased once the computer is switched off), ROM is non-volatile.

1.8 KEYWORDS

Application Software : Application programs are written individually to operate specific tailor-made procedures and systems.

Central Processing Unit (CPU) : The Central Processing Unit, often called processor or just CPU, comprises Control Unit, the Arithmetic and Logic Unit (ALU), and the Primary Memory.

Hardware : Physical equipment of a computer system.

Random Access Memory (RAM) : The memory that stores the data and/ or program of the currently executing tasks.

Read Only Memory (ROM) : The memory that is usually used to store programs and/or data that must be available to the computer when the power is turned on.

Software : Software is a general term that refers to computer programs which are collectively stored on secondary storage media.

System Software : It is designed to act as an interface between users or their application programs and the computer system itself.

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