Chapter 2

Input Output Media

This chapter deals with two basic computer unitsinput and output devices. Input devices are used to enter the data and instructions into the computer system before any processing can be performed. Output devices are used for the conversion of machine-readable information into human-readable form. The chapter discusses some commonly used input devices including keyboard, mouse, joystick, scanner, and optical scanners. The functions of all these input devices along with the hard copy and soft copy output devices under which, various types of printers and plotters have been explored. Next display devices such as CRT monitors, LCD monitors and speech synthesisers are explained. The chapter concludes by giving an overview of computer terminals.

2.1 Introduction

Previously, we discussed that a computer accepts input and processes it to get a desired output according to the sequence of instructions. Essentially, a computer system consists of four components: input devices, CPU, output devices and memory. Input devices are used to provide data to the CPU for processing. After

processing, the input data is converted into meaningful information and this output is presented to the user with the help of output devices. In computer terminology, a device can be referred to as a unit of hardware, which is capable of providing input to the computer or receiving output, or both.

An input device is an electromechanical device that allows the user to feed information into the computer for analysis, storage and to give commands to the computer. Data and instructions are entered into the computer's memory through an input device. It captures information and translates it into a form that can be processed and used by the other parts of the computer. After processing the in- put data, the computer provides the results with the help of output devices. An output device converts machine-readable information into human-readable form. The basic functioning of the output device is just the opposite of the input device,that is, the data is "fed into" the computer system through the input device while the output is "taken out" from the computer through the output device. However,the output, which comes out from the CPU, is in the form of digital signals (see Figure 2.1). The output devices display the processed information by converting them into graphical, alphanumeric, or audio-visual form.

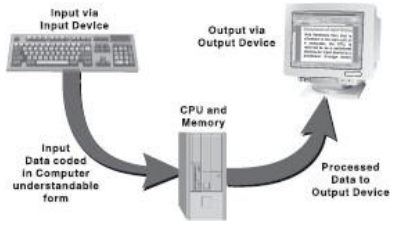

Figure 2.1: Data Processing

2.1.1 Importance of Input/Output Devices

As we know, the processing of the data by the computer system can be viewed as a three-step process:

- **Step 1:** Data input via an input device.

- **Step 2:** Processing of data.
- **Step 3:** Data output via an output device.

Input devices play a major role in the processing of any data via the computer system because the output of the computer is always based on the given input. Generally, data that is given to the input devices is raw. Therefore, it is the function of the input devices to manipulate the raw data and then send them for further processing. The preparation of the computerized input is the initial step in the creation of useful output. This output must be supplied to the outside world, which is done through output devices.

2.2 Types of Input Devices

Computer accepts input in two ways, either manually or directly. In case of manual data entry, the user enters the data into computer by hand, for example, by using keyboard and mouse. A user can also enter data directly by transferring information automatically from a source document (like from a cheque using MICR) into the computer. The user does not need to enter information manually. Direct data entry is accomplished by using special direct data entry devices like a barcode reader. Some of the commonly used input devices are keyboard, pointing devices like mouse and joystick, speech recognition, digital camera and scanners.

2.2.1 Keyboard

A keyboard is the most common data entry device. Using a keyboard, the user can type text and commands. The keyboard is designed to resemble a regular typewriter with a few additional keys (see Figure 2.2). Data is entered into the computer by simply pressing keys. The layout of the keyboard has changed very little since it was introduced. In fact, the most common change in its technology

has simply been the natural evolution of adding more keys that provide additional functionality. The number of keys on a typical keyboard varies from 84 to 104.

Qwerty Query

The layout of a keyboard comes in various styles, such as QWERTY, AZERTY and DVORAK. QWERTY is the most common layout in English language computer keyboards. It takes its name from the first six letters shown on the keyboard's top row of letters. Similarly, French language keyboards use A and Z in place of Q and W and are known as AZERTY keyboards.

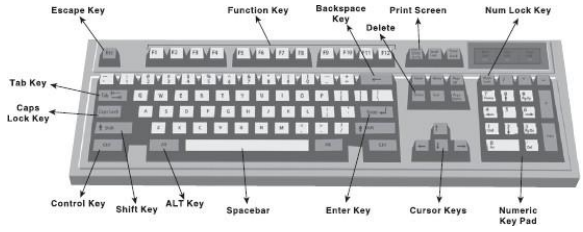

Figure 2.2: Keyboard

Portable computers such as laptops quite often have custom keyboards that have slightly different key arrangements than a standard keyboard. In addition, many system manufacturers add special buttons to the standard layout. A keyboard is the easiest input device, as it does not require any special skill. Usually, it is supplied with a computer so no additional cost is incurred. The maintenance and operational cost of a keyboard is also less. However, using a keyboard for data entry may be a slow process because the user has to manually type all the text. In addition, it can be difficult for people suffering from muscular disorders.

2.2.2 Pointing Devices

Most computers come with an alphanumeric keyboard but in some applications, the keyboard is not convenient. For example, if the user wants to select an item

from a list, the user can identify that item's position by selecting it through the keyboard. However, this action could be performed quickly by pointing at the correct position. A pointing device is used to communicate with the computer by pointing to locations on the monitor screen. Such devices do not require keying of characters; instead the user can move a cursor on the screen and perform move, click, or drag operations. Some of the commonly used pointing devices are mouse, trackball, joystick, light pen, touch screen and trackpad.

Mouse: A Mouse is a small handheld pointing device with a rubber ball embedded at its lower side and buttons on the top. Usually, a mouse contains two or three buttons, which can be used to input commands or information (see Figure 2.3). It may be classified as a mechanical mouse or an optical mouse, based on the technology it uses. A mechanical mouse uses a rubber ball at the bottom surface, which rotates as the mouse is moved along a flat surface, to move the cursor. It is the most common and least expensive pointing device. An optical mouse uses a light beam instead of a rotating ball to detect movement across a specially patterned mouse pad. As the user rolls the mouse on a flat surface, the cursor on the screen also moves in the direction of the mouse's movement. It is pricier than their mechanical counterparts but are accurate and often do not need a mouse pad.

Figure 2.3: Mouse

A mouse allows us to create graphic elements on the screen such as lines, curves and freehand shapes. Since it is an intuitive device, it is easier and convenient to work as compared to the keyboard. Like a keyboard, it is also supplied with a computer; therefore, no additional cost is incurred. However, it needs a flat space close to the computer. The mouse cannot easily be used with laptop (notebook) or

palmtop computers. These types of computers need a trackball or a touch sensitive pad called a touchpad.

Trackball: A Trackball is another pointing device that resembles a ball nestled in a square cradle and serves as an alternative to a mouse. In general, a trackball is as if a mouse is turned upside down (see Figure 2.4). It has a ball, which can be rotated by fingers in any direction, the cursor moves accordingly. The size of the ball in the trackball varies from as large as a cue ball, to as small as a marble.Since it is a static device, instead of rolling the mouse on the top of the table the ball on the top is moved by using fingers, thumbs and palms. This pointing devicecomes in various shapes and forms but with the same functions. The three shapes,which are commonly used are a ball, button and square.

Figure 2.4: Trackball

Joystick: A joystick is a device that moves in all directions and controls the movement of the cursor. The basic design of a joystick consists of a stick that is attached to a plastic base with a flexible rubber sheath. This plastic base houses a circuit board that sits beneath the stick. The electronic circuitry measures the movement of the stick from its central position and sends the information for processing. A joystick also consists of buttons which can be programmed to indicate certain actions once a position on the screen has been selected using stick (see Figure 2.5). It offers three Joystick types of control: digital, glide and direct. Digital control allows movement in a limited number of directions such as up, down, left and right. Glide and direct control allow movements in all directions (360). Direct control joysticks have the added ability to respond to the distance and speed with which

the user moves the stick.

Figure 2.5: Joystick

Light Pen: A light pen (sometimes called mouse pen) is a hand-held electro-optical pointing device which a when touched to or aimed closely at a connected computer monitor, will allow the computer to determine where on that screen the pen is aimed. It facilitates drawing images and selects objects on the display screen by directly pointing to the objects. It is a pen-like device, which is connected to the machine by a cable (see Figure 4.10). Although named light pen, it actually does not emit light but its light-sensitive diode would sense the light coming fromthe screen. The light coming from the screen causes the photocell Figure 2.6 LightPen to respond by generating a pulse. This electric response is transmitted to the processor that identifies the position to which the light pen is pointing. With the movement of light pen over the screen, the lines or images are drawn.

Figure 2.6: Light Pen

Light pens give the user the full range of mouse capabilities without the use of a pad or any horizontal surface. Using light pens, users can interact more easily with

applications, in such modes as drag and drop, or highlighting. It is used directly on the monitor screen and it does not require any special hand-eye coordinating skills. Pushing the light pen tip against the screen activates a switch, which allows the user to make menu selections, draw and perform other input functions. Light pens are perfect for applications where desk space is limited, in harsh workplace environments, and any situation where fast accurate input is desired. It is very useful to identify a specific location on the screen. However, it does not provide any information when held over a blank part of the screen. A light pen is economically priced and requires little or no maintenance.

Touch Screen: A touch screen is a special kind of input device that allows the direct selection of a menu item or the desired icon with the touch of finger (see Figure 2.7). Essentially, it registers the input when a finger or other object is touched to the screen. It is normally used when information has to be accessed with minimum effort. However, it is not suitable for input of large amounts of data. Typically, it is used in information-providing systems like hospitals, airlines and railway reservation counters, amusement parks, and so on.

Figure 2.7: Touch Screen

The controller connects the touch sensor and the computer. It takes information from the touch sensor and translates it into information that a computer can understand. The driver is a software update for the computer system that allows the touch screen and computer to work together. It tells the operating system how to

interpret the touch event information that is sent from the controller.

Trackpad: Trackpad (also referred to as touchpad) is a stationary pointing device that works by sensing the movement of fingers across a small sensitive surface (1.5 or 2 inches) and translating them into the pointer movement on the screen (see Figure 2.8). It is generally used in laptops but can also be connected to a PC through a cord. It is also equipped in personal digital assistants (PDAs) and media players such as the iPod. Typically, a trackpad also consists of two or three buttons which work as mouse buttons. Many trackpads are also strike sensitive, that is, the user can tap on the trackpad to perform operations like selecting an object, maximizing/ minimizing the window, etc.

Figure 2.8: Trackpad

Note: The device manufactured by Apple is referred to as Trackpad while the device manufactured by others is known as Touchpad.

2.2.3 Speech Recognition

Speech recognition is one of the most interactive systems to communicate with the computer. The user can simply instruct the computer, with the help of a micro-phone (along with a speech recognition software), to perform a task (see Figure 2.9). It is the technology by which sounds, words or phrases spoken by humans are converted into digital signals, and these signals are transformed into computer-

generated text or commands. Most speech recognition systems are speaker-dependent so they must be separately trained for each individual user. The speech recognition system "learns" the voice of the user, who speaks isolated words repeatedly. Then, these voiced words are recognizable in the future.

Figure 2.9: Trackpad

Speech recognition is gaining popularity in the corporate world among non-typists, people with disabilities, and business travellers who record information for later transcription. The computer-based speech-recognition systems can be used to create text documents such as letters or e-mails, to browse the Internet, and to navigate among applications by voice commands. They have relatively high accuracy rates. They allow the user to communicate with the computer directly without using a keyboard or a mouse. However, as compared to other input devices, the reliability of the speech recognizer is lesser. Sometimes, it is unable to differentiate between two similar sounding words such as see and sea. It is also not suitable for noisy places.

2.2.4 Digital Camera

A Digital camera, as shown in Figure 2.10, stores images digitally rather than recording them on a film. Once a picture has been taken, it can be transferred to a computer system and then manipulated with an image editing software, and printed. The big advantage of digital cameras is that making photos is both inexpensive and fast because there is no film processing.

Figure 2.10: Digital Camera

2.2.5 Webcam

A webcam (short form of web camera) is a portable video camera, which captures live video or images that may be viewed in real time over a network or the Internet. It is just a small digital camera that is either built in your computer (in most laptops) or can be connected through a USB port (see Figure 2.11). It is normally placed on top of the PC monitor or laptop to capture images of the user while he/she is working on the computer.

Figure 2.11: Webcam

Nowadays, a wide variety of webcams are available, and according to their varied capabilities and features, they are classified into two categories, namely, streaming and snapshot. A streaming webcam captures moving images (about 30 images per second), thus creating a streaming videoa web video that plays on the computer immediately as its data arrive via network; the recipient need not download the video. However, a high-speed Internet connection is needed to transfer the video smoothly, and the image quality is also comparatively poor. On the other hand, a snapshot webcam captures only still images (usually, once every 30 seconds) and refreshes it continuously. It produces better quality images and is easier to configure than streaming videos.

The popularity of webcams is increasing everyday due to their unlimited uses. The most popular use of webcams is in videoconferencing to provide real-time communication where groups of people can see and interact with each other. It can be used with various messenger programs like Yahoo and Windows Live Messenger where you can share your videos while instant messaging with somebody. It is also being used in educational institutions to conduct distance-learning activities; one can attend the classes sitting at home only.

Webcams are cheap, compact and are easy to install and use. They are affordable because of their low manufacturing cost. However, a major drawback of using webcams is that they produce only real-time images and cannot be used unless attached with the PC. Some webcams also comprise advanced features such as automatic lightning controls, automatic face tracking and autofocus, which increase their cost.

2.2.6 Scanners

There are a number of situations when some information (picture or text) is available on paper and is needed on the computer for further manipulation. A scanner is an input device that converts a document into an electronic format that can be stored on the disk. The electronic image can be edited, manipulated, combined and printed by using the image editing software. Scanners are also called optical scanners as they use a light beam to scan the input data.

Note that most scanners come with a utility program that allow them to communicate with the computer and save the scanned images as a graphic files on the computer. Moreover, they can store images in both greyscale and colour mode. The two most common types of scanners are hand-held scanners and flatbed scanners.

Hand-held Scanner: A hand-held scanner consists of LEDs, which are placed

over the document to be scanned (see Figure 2.12). This scanner performs the scanning of the document very slowly from the top to the bottom with its light on. In this process, all the documents are converted and then stored as images. While working, the scanner is dragged very steadily and carefully over the document at a constant speed without stopping or jerking in order to obtain best results. Hand-held scanners are widely used where high accuracy is not of much importance. The size of the hand-held scanners is small. They come in various resolutions, up to about 800 dpi (dots per inch) and are available in either greyscale or colour. Furthermore, they are used when the volume of the documents to be scanned is low. These devices read the data on price tags, shipping labels, inventory part numbers, book ISBNs and so on.

Figure 2.12: Hand-held Scanner

Flatbed Scanner: A flatbed scanner looks similar to a photocopier machine. It consists of a box containing a glass plate on its top and a lid that covers the glass plate (see Figure 2.13). This glass plate is used for placing the document to be scanned. The light beam is placed below the glass plate and when it is activated, it moves horizontally from left to right. After scanning one line, the light beam moves in order to scan the next line and the procedure is repeated until all the lines are scanned. Scanning an A4 size document takes about 20 seconds. These scanners can scan black and white as well as colour images. Flatbed scanners are larger in size and more expensive than hand-held scanners. However, they usually produce better quality images because they employ better scanning technology.

Figure 2.13: Flatbed Scanner

Some scanners use a three-pass scanning method. Each pass uses a Working of a Flatbed Scanner different colour filter (red, green or blue) between the lens and CCD array. After the three passes are completed, the scanner software assembles the three filtered images into a single full-colour image. Nowadays, most scanners use the single-pass method. The lens splits the image into three smaller versions of the original image. Each smaller version passes through a colour filter (either red, green or blue) onto a discrete section of the CCD array. The scanner combines the data from the three parts of the CCD array into a single full-colour image, which is then sent to the computer.

2.2.7 Optical Character Recognition

As stated earlier, a scanner converts an input document into an electronic format that can be stored on the disk. If the document to be scanned contains an image, it can be manipulated using image editing software. However, if the document to be scanned contains text, you need an optical character recognition (OCR) software. This is because when the scanner scans a document, the scanned document is stored as a bitmap in the computer's memory. The OCR software translates the bitmap image of text to the ASCII codes that the computer can interpret as letters, numbers and special characters.

Because of OCR, data entry becomes easier, error-free and less time consuming.

However, it is very expensive and if the document is not typed properly, it will become difficult for the OCR to recognize the characters. Furthermore, except for tab stops and paragraph marks, most document formatting is lost during text scanning. The output from a finished text scan will be a single column editable text file. This text file will always require spell checking and proof reading as well as re-formatting to get the desired final layout.

2.2.8 Optical Mark Recognition

Optical mark recognition (OMR) is the process of detecting the presence of intended marked responses. A mark registers significantly less light than the surrounding paper. Optical mark reading is done by a special device known as optical mark reader. In order to be detected by the OMR reader, a mark has to be positioned correctly on the paper and should be significantly darker than the surrounding paper. The OMR technology enables a high-speed reading of large quantities of data and transferring this data to a computer without using a keyboard. Generally, this technology is used to read answer sheets (objective type tests). In this method, special printed forms/documents are printed with boxes, which can be marked with a dark pencil or ink (see Figure 2.14). These forms are then passed under a light source and the presence of dark ink is transformed into electric pulses, which are transmitted to the computer.

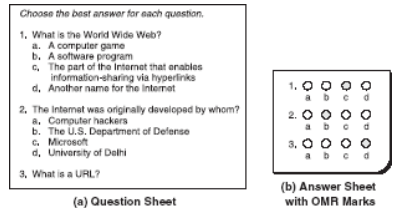

Figure 2.14: Questionnaire Using OMR Marks

OMR has a better recognition rate than OCR because fewer mistakes are made by machines to read marks than in reading handwritten characters. Large volumes of

data can be collected quickly and easily without the need for specially trained staff. Usually, an OMR reader can maintain a throughput of 1500 to 10,000 forms per hour. However, the designing of documents for optical mark recognition is complicated and the OMR reader needs to be reprogrammed for each new document design. OMR readers are relatively slow because the person putting marks on the documents must follow the instructions precisely. Any folding or dirt on a form may prevent the form from being read correctly. In addition, it requires accurate alignment of printing on forms and needs a paper of good quality.

2.2.9 Magnetic-ink Character Recognition

You must have seen special magnetic encoding using characters printed on the bottom of a cheque (see Figure 2.15). The characters are printed using special ink, which contains iron particles that can be magnetized. To recognize these magnetic ink characters, a Magnetic ink character reader (MICR) is used. It reads the characters by examining their shapes in a matrix form and the information is then passed on to the computer.

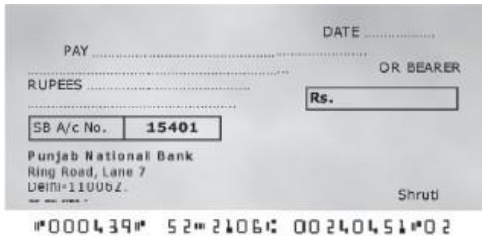

Figure 2.15: Cheque Number Written in MICR Font

The banking industry prefers MICR to OCR as MICR gives extra security against forgeries such as colour copies of payroll cheques or hand-altered characters on a cheque. If a document has been forged, say a counterfeit check produced usinga colour photocopying machine, the magnetic-ink line will either not respond to magnetic fields, or will produce an incorrect code when scanned using a device

designed to recover the information in the magnetic characters. The reading speed of the MICR is also higher. This method is very efficient and time saving for data processing.

2.2.10 Bar Code Reader

Bar code is a machine-readable code in the form of a pattern of parallel vertical lines of varying widths. It is commonly used for labelling goods that are available in super markets and numbering books in libraries. This code is sensed and read by a bar code reader using reflective light (see Figure 2.16). The information recorded in the bar code reader is then fed into the computer, which recognizes the information from the thickness and spacing of bars. Bar code readers are either hand-held or fixed-mount. Hand-held scanners are used to read bar codes on stationary items. With fixed-mount scanners, items having a bar code are passed by the scanner by hand, as in retail scanning applications or by conveyor belts in many industrial applications.

Figure 2.16: Bar Code Reader

Bar code data correction systems provide enormous benefits for just about every business with a bar code data-collection solution; capturing data is faster and more accurate. A bar code scanner can record data five to seven times faster than a skilled typist. A bar code data entry has an error rate of about 1 in 3 million. Bar coding also reduces cost in terms of labour and revenue losses resulting from data collection errors. Bar code readers are widely used in supermarkets, department stores, libraries and other places. You must have seen bar code on the back cover of certain books and greeting cards. Retail and grocery stores use a bar code reader

to determine the item being sold and to retrieve the item price from a computer system.

Bar code scanners are electro-optical systems that include a means of illuminating the symbol and measuring reflected light. The light waveform data are converted from analog to digital, in order to be processed by a decoder, and then transmitted to the computer software. The process begins when a device directs a light beam over a bar code. The device contains a small sensory reading element, called sensor, which detects the light being reflected back from the bar code, and converts light energy into electrical energy. The result is an electrical signal that can be converted into alphanumeric data. The pen in the bar code unit reads the information stored in the bar code and converts it into a series of ASCII characters by which the operating system gets the information stored in the bar code.

2.3 Types of Output Devices

Output is data that have been processed into useful information. It can be displayed or viewed on a monitor, printed on a printer, or listened through speakers or a headset. Generally, there are two basic categories of output: the output which can be readily understood and used by humans, and which is stored on secondary storage devices so that the data can be used as input for further processing. The output which can be easily understood and used by human beings are of the following two forms:

- **Hard Copy:** The physical form of output is known as hard copy. In general, it refers to the recorded information copied from a computer onto paper or some other durable surface such as microfilm. Hard copy output is permanent and a relatively stable form of output. This type of output is also highly portable. Paper is one of the most widely used hard copy output media. The principal examples are printouts, whether text or graphics from printers.

- **Soft Copy:** The electronic version of an output, which usually resides in computer memory and/or on disk, is known as soft copy. Unlike hard copy, soft copy is not a permanent form of output. It is transient and is usually displayed on the screen. This kind of output is not tangible, that is, it cannot be touched. Soft copy output includes audio and visual form of output, which is generated using a computer. In addition, textual or graphical information displayed on a computer monitor is also a soft copy form of output.

Based on the hard copy and soft copy outputs, the output devices are classified into hard copy and soft copy output devices. Printers, plotters and microfilms are the most commonly used hard copy output devices while monitors, voice response systems, projectors, electronic whiteboards, and headphones and headsets are some commonly used soft copy output devices.

2.3.1 Printers

Ever since the dawn of computer age, producing printed output on paper has been one of the computer's principal functions. A printer prints information and data from the computer onto paper. Generally, the printer prints 80 or l32 columns of characters in each line, and prints either on single sheets or on a continuous roll of paper, depending upon the printer itself. The quality of a printer is determined by the clarity of a print it can produce, that is, its resolution. Resolution is used to describe the sharpness and clarity of an image. The higher the resolution, the better the image. For printers, the resolution is measured in dpi (dots per inch). The more the dpi, the better will be the quality of image. The dots are so small and close together that they project the image as a solid one. If a printer has a resolution of 600 dpi, it means that the printer is capable of printing 360,000 dotsper square inch.

Printers are divided into two basic categories: impact printers and non-impact

printers. As their names specify, impact printers work by physically striking a head or needle against an ink ribbon to make a mark on the paper. This includes dot matrix printers, daisy wheel printers and drum printers. In contrast, ink-jet and laser printers are non-impact printers. They use techniques other than physically striking the page to transfer ink onto the page.

Dot Matrix Printer: *Dot matrix printer* (also known as the wire matrix printer) uses the oldest printing technology and it prints one character at a time (see Figure 2.17). It prints characters and images as pattern of dots. The speed of dot matrix printers is measured in characters per second (cps). Most dot matrix printers offer different speeds depending on the quality of print desired. The speed can vary from about 200 to over 500 cps. The print quality is determined by the number of pins (the mechanisms that print the dots), which can vary from 9 to 24. The more pins per inch, the Figure 2.17 Dot Matrix higher the print resolution. The best dot matrix printers Printer (24 pins) can produce near letter-quality-type image. Most dot matrix printers have a resolution ranging from 72 to 360 dpi.

Figure 2.17: Dot Matirx Printer

Dot matrix printers are inexpensive and have low operating costs. These printers are able to use different types of fonts, different line densities and different types of paper. Many dot matrix printers are bi-directional, that is, they can print the characters from either direction– left or right. The major limitation of the dot matrix printer is that it prints only in black and white. In addition, as compared to printers like laser printers, they produce low to medium quality printing. The image printing ability is also very limited. These printers may not be able to print graphic objects adequately but can handle applications such as accounting, per-

sonnel and payroll very well. Dot matrix printers are commonly used in low-cost, low-quality applications like cash registers. These printers are limited to situations where carbon copies are needed and the quality is not too important.

Daisy Wheel Printer: The major drawback of the dot matrix printer is that the pattern of dots that make up each character is visible on the print produced by it, making it look unprofessional. If you need a printer that can produce professional letter quality documents, you need a daisy wheel printer. The daisy wheel printer is named so because the print head of this printer resembles a daisy flower, with printing arms that appear like the petals of the flower (see Figure 2.18). These printers are commonly referred to as letter quality printers as the print quality is as good as that of a high-quality typewriter.

Figure 2.18: Daisy Wheel Printer

Daisy wheel printers produce high-resolution output and are more reliable than dot matrix printers. They can have speeds up to 90 cps. These printers are also called smart printers because of their bi-directional printing and built-in micro-processor control features. However, daisy wheel printers give only alphanumeric output. They cannot print graphics and cannot change fonts unless the print wheel is physically replaced. These printers are usually very slow because of the time required to rotate the print wheel for each character desired. Daisy wheel printers are slower and more expensive than dot matrix printers. However, if the appearance of the correspondence is important and you do not need graphics, a daisy wheel printer is a better choice.

Drum Printer: The dot matrix and daisy wheel printers are character or serial printers, that is, they print one character at a time. However, a drum printer (shown

in Figure 2.19) is a line printer, that is, it can print a line in a single operation. Generally, a line printer is used because of its speed as it uses special tractor-fed paper with pre-punched holes along each side. This arrangement allows a continuous high-speed printing. Its printing speed varies from 300 lines to 2000 lines per minute with 96160 characters on a 15-inch line. Although such printers are much faster than character printers, they tend to be quite loud, have limited multi-font capability and often produce lower print quality than most recent printing technologies. Line printers are designed for heavy printing applications. For example, in businesses where enormous amounts of materials are printed, the low-speed character printers are very slow; therefore, the users need high-speed line printers. Although, drum printers have high speed of printing, they are very expensive and their character fonts cannot be changed. Moreover, the strike of the hammer should be precise. A single mistimed strike of the hammer may lead to wavy and slightly blurred printing.

Figure 2.19: Drum Printer

Ink-jet Printer: The most common type of printer found in homes today is the ink-jet printer (see Figure 2.20). An ink-jet printer is a printer that places extremely small droplets of ink onto paper to create an image. Being a non-impact printer, it does not touch the paper while creating an image. Instead, it uses a series of nozzles to spray drops of ink directly onto the paper. Inkjets were origi-nally manufactured to print in monochrome (black and white) only. However, theprint head has now been expanded and the nozzles increased to accommodate cyan (C), magenta (M), yellow (Y) and black (K). This combination of colours is called

CMYK. It allows for printing images with nearly Figure 2.20 Ink-jet Printer the same quality as a photo development lab using certain types of coated paper.

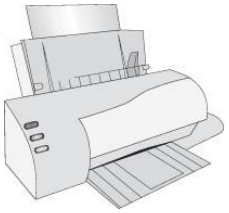

Figure 2.20: Ink-Jet Printer

Ink-jet printers are costlier than dot matrix printers and the quality is much better. These printers can print any shape of character, which a user can specify, as they produce printed output as patterns of tiny dots. This allows the printer to print many special characters, different sizes of prints, and enables it to print graphics such as charts and graphs. Ink-jet printers typically print with a resolution of 600 dpi or more. Due to the high resolution, these printers produce high quality graphics and text printouts. They are also affordable, which appeals to small businesses and home offices. These printers print documents at a medium pace but slow down if printing a document with multi-colours. These printers can print about six pages a minute and can be programmed to print symbols such as Japanese or Chinese characters.

Laser Printer: A laser printer provides the highest quality text and images for personal computers today (see Figure 2.21). It is a very fast printer, which operates on the same principle as that of a photocopy machine. Most laser printers can print text and graphics with a very high quality resolution. They are also known as page printers because they process and store the entire page before they actually print it. They produce sharp, crisp images of both text and graphics, providing resolutions from 300 to 2400 dpi. Today, the resolution of most printers is 600 dpi. They are quiet and fast, are able to print 4-32 text-only pages per minute for individual microcomputers and up to 200 pages per minute for mainframes.

Laser printers can print in excess of 2000 lines per minute. Furthermore, they can print in different fonts, that is, type styles and sizes. Laser printers are often faster than ink-jet printers but are more expensive to buy and maintain than the other printers. The cost of these printers depends on a combination of costs of paper, toner replacement, and drum replacement. These printers are useful for volume printing because of their speed.

Figure 2.21: Laser Printer

Hydra Printer: Hybrid document reproduction apparatus (HYDRA) printer, popularly known as all-in-one printer, is a device that consolidates the capabilities of multiple devices in one machine (see Figure 2.22). It may include some or all of the devices like printer, scanner, photocopier and fax machine. Apart from these devices, some hydra printers contain memory card slots which facilitate easier printing of photos and also have the in-built wireless capabilities that make Hydra Printer sharing of this printer with other systems easier.

Figure 2.22: Hydra Printer

Following are the features that must be considered to evaluate these printers:

- Print speed

- Maximum resolution
- Memory card compatibility
- Scanner resolution
- Fax speed

Hydra printers are useful for small organizations due to their small size, less space requirement and cost effectiveness. The cost of these printers depend on the technology (inkjet or laser) being used. They save power to a great extent as only one power outlet is required for performing various operations. They are easy to install and maintain and have easy-to-use GUI (graphical user interface) that help users to understand their functions easily.

2.3.2 Plotters

A plotter is a pen-based output device that is attached to a computer for making vector graphics, that is, images created by a series of many straight lines. It is used to draw high-resolution charts, graphs, blueprints, maps, circuit diagrams and other line-based diagrams. It is similar to a printer, but it draws lines using a pen. As a result, it can produce continuous lines, whereas a printer can only simulate lines by printing a closely spaced series of dots. Multicolour plotter uses different coloured pens to draw different colours. Colour plots can be made by using four pens (cyan, magenta, yellow and black) and need no human intervention to change them.

Being vector-based, a plotter tends to draw much crisper lines and graphics. The lines drawn by these devices are continuous and very accurate. However, the plotter is considered a very slow output device because it requires excessive mechanical movement to plot. Furthermore, it is unable to produce solid fills and shading. Plotters are relatively expensive as compared to printers but can produce more printouts than standard printers. They are mainly used for Computer Aided

Design (CAD) and Computer Aided Manufacturing (CAM) applications such as printing out plans for houses or car parts. These are also used with programs like AUTOCAD (computer assisted drafting) to give graphic outputs. As shown in Figure 2.23, there are two different types of plotters: drum plotter (where the paper moves) and flatbed plotter (where the paper is stationary).

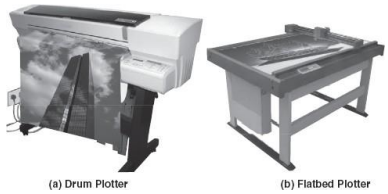

Figure 2.23: Plotters

- **Drum Plotter:** In drum plotters, the paper on which the design is to be printed is placed over a drum. These plotters consist of one or more pen(s) that are mounted on a carriage which is horizontally placed across the drum. The drum can rotate in either clockwise or anticlockwise direction under the control of plotting instructions sent by the computer. In case a horizontal line is to be drawn, the horizontal movement of the pen is combined with the vertical movement of the page via the drum. The curves can also be drawn by creating a sequence of very short straight lines. In these plotters, each pen can have an ink of a different colour to produce multicolour designs. Drum plotters are used to produce continuous output such as plotting earthquake activity or for long graphic output such as tall building structures.

- **Flatbed Plotter:** Flatbed plotters consist of a stationary, horizontal plotting surface on which paper is fixed. The pen is mounted on a carriage, which can move horizontally, vertically, leftwards or rightwards to draw lines. In flatbed plotters, the paper does not move, the pen-holding mechanism provides all the motion. These plotters are instructed by the computer on the movement of pens in the x - y coordinates on the page. These plotters are capable of

working on any standard, that is, from A4 size paper to some very big beds. Depending on the size of the flatbed surface, these are used in designing of ships, aircrafts, buildings and so on. The major disadvantage of this plotter is that it is a slow output device and can take hours to complete a complex drawing.

2.3.3 Monitor

The monitor is the most frequently used output device for producing soft-copy output. A computer monitor is a TV-like display attached to the computer on which the output can be displayed and viewed. The computer monitor can either be a monochrome display or a colour display. A monochrome screen uses only one colour (usually white, green, amber or black) to display text on contrasting background. Colour screens commonly display 256 colours at one time from a selection of over 256,000 choices. Monitors are available in various sizes like 14, 15, 17, 19 and 21 inches. The size of the display is described based on two parameters: aspect ratio and screen size (see Figure 2.24). Aspect ratio is the ratio of the width of the display screen to the height, that is, the ratio of vertical points to the horizontal points necessary to produce equal-length lines in both directions on the screen. Generally, computer displays have an aspect ratio of 4:3. Like televisions, screen sizes are normally measured diagonally (in inches), the distance from one corner to the opposite corner.

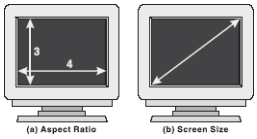

Figure 2.24: Aspect Ratio and Screen Size

Sometimes, while watching television, you may notice that the picture looks a bit blurred. The reason behind this is that the displayed image is not solid but is

created by the configurations of dots. These dots are known as picture elements, pels, or simply pixels. The golden rule of a sharp image is that the more the pixels, the sharper the picture. The screen clarity depends on three basic qualities:

- **Resolution:** It refers to the number of pixels in the horizontal and vertical directions on the screen. In medium-resolution graphics, pixels are large, whereas in high-resolution graphics, pixels are small. The average CRT display is currently 800 600 or 1024 768. The more dots, or pixels, available to create the image, the sharper it will be. Therefore, a resolution of 1024 768 will produce sharper images (for example, smaller icons and more information) than one of 640 480.

- **Dot Pitch:** It is the measurement of the diagonal distance between two like-coloured (red, green or blue) pixels on a display screen. It is measured in millimetres and common dot pitches are .51 mm, .31 mm, Pixel .28 mm, .27 mm, .26 mm and .25 mm. The Figure 4.44 Dot Pitch smaller the dot pitch, the sharper will be the image when displayed on the monitor. Generally, a dot pitch of less than .31 mm provides clear images. Multimedia and desktop-publishing users typically use .25 mm dot-pitch monitors (see Figure 2.25).

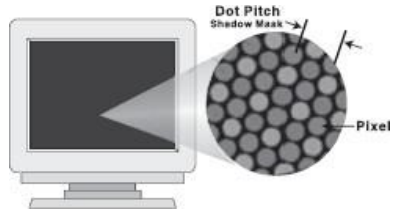

Figure 2.25: Dot Pitch

- **Refresh Rate:** It is the number of times per second the pixels are recharged so that their glow remains bright. Normally, screen pixels are made from phosphor. An electron beam strikes the phosphor and causes it to emit light, resulting in the display of the image. However, it needs to be Refreshed

periodically because the phosphors hold their glow for just a fraction of a second. The Refresh rate for a monitor is measured in Hertz (Hz) and varies from 60 to 75 Hz. A Refresh rate of 60 Hz means image is redrawn 60 times a second. The higher the Refresh rate, the more solid the image looks on the screen, that is, it does not flicker.

Colour Depth: Colour depth, also referred to as bit depth, refers to the number of bits assigned to each pixel in the image and the number of colours that can be created from those bits. In simple words, it refers to the number of colours that a monitor can display. Different colour depths depend on the amount of display memory dedicated to each pixel. One byte is used to represent 256 colours for each pixel, 16 bits (or 2 bytes) per pixel allows up to 65535 colours, and 24-bit (or 3 bytes) colour can display 16.8 million different colours per pixel. 8-bit colour is better known as pseudo colour, 16-bit mode as high colour, and 24-bit mode is called true colour. A video display unit consists of a video card or adapter that is fitted into an expansion slot and a compatible visual display, which is compatible with the video adapter. The combination of the display modes supported by the graphics adapter and the colour capability of the monitor determine how many colours can be displayed.

Cathode Ray Tube Monitors: Nowadays, most computer monitors are based on cathode ray ube (CRT) technology. The basic operation of these tubes is similar to that in television sets. Figure 2.26 illustrates the basic components of a CRT.

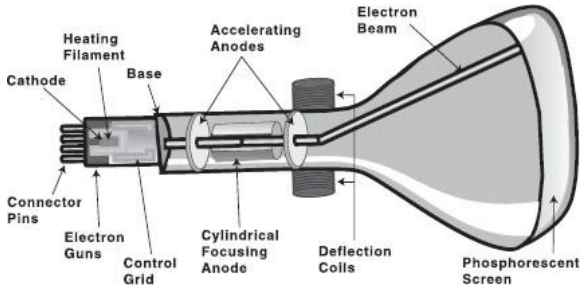

Figure 2.26: Cathode Ray Tube

A beam of electrons (cathode rays) emitted by an electron gun passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor-coated screen. The phosphor then emits a small spot of light at each position contacted by the beam. When the electron beam strikes the phosphors, the light is emitted for a short period of time, this condition is known as persistence. Technically, persistence is defined as the time it takes for the emitted light from the screen to decay to 1/10 of its original intensity. Graphics monitors are usually constructed with persistence in the range of 10-60 microseconds. Since the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture. One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points. This type of display is called a Refresh CRT.

Liquid Crystal Display Monitors: In the previous section, we discussed the most popular CRT monitors that are used as display devices. With the widespread use of smaller computers like PDAs and laptops, a new type of display, Liquid Crystal Display (LCD), has made a big impact on the computer market. LCD screens have been used for long on notebook computers but are also becoming popular as desktop monitors.

The term liquid crystal sounds like a contradiction. We generally conceive a crystal as a solid material like quartz and a liquid as water-like fluid. However, some substances can exist in an odd state that is semi-liquid and semi-solid. When they are in this state, their molecules tend to maintain their orientation like the molecules in a solid, but also move around to different positions like the molecules in a liquid. Thus, liquid crystals are neither a solid nor a liquid. Manufacturers use this amazing ability of liquid crystals to display images.

An LCD screen is a collection of multiple layers as shown in Figure 2.27. A fluorescent light source, known as the backlight, makes up the rearmost layer. Light passes through the first of two polarizing filters. The polarized light then passes

through a layer that contains thousands of liquid crystal blobs aligned in tiny containers called cells. These cells are aligned in rows across the Figure 2.27 Coloured Liquid Crystal Screen screen; one or more cells make up one pixel. Electric leads around the edge of the LCD create an electric field that twists the crystal molecule, which lines the light up with the second polarizing filter and allows it to pass through.

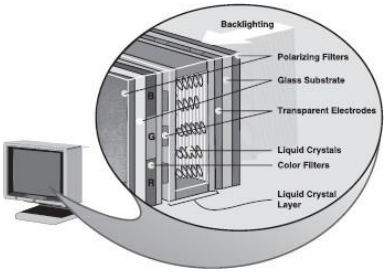

Figure 2.27: Coloured Liquid Crystal Screen

Differences between LCD and CRT: Although both the CRT and LCD monitors are the most frequently used types of displays in computers, they are worlds apart in terms of what is important when making a purchase decision. Here is a brief discussion of what is different about LCD monitors.

- **Size:** LCD is lightweight and compact, which saves desktop space as compared to a CRT.
- **Resolution:** LCD is designed to work in a single resolution while CRT is designed for many resolutions.
- **Pixel Density:** Pixel density of LCD is generally not as tight as the dot pitch in CRT but for most applications, the density is acceptable.
- **Brightness:** The illuminated phosphor of a CRT is not nearly as bright as what the LCD can produce with its florescent backlight.
- **Power Consumption:** LCD consumes significantly less power than CRT

and has a low emission risk. Typically, a LCD consumes approximately half of the power of a typical CRT.

- Flicker: With CRT monitors, the goal is to get a faster Refresh rate of at least 85 Hz,but LCD monitors are designed to run at a much slower Refresh rate (usually about 60 Hz) and flicker is never an issue.
- **Pixel Response Time:** The time taken by a pixel to change its state is called pixel response time. CRT has extremely fast pixel response time but LCD can be quite slow. As a result, the user might see ghost images when there is movement on the screen. The fastest LCD monitors today have a response time of 25 milliseconds, which is still only about half the speed of a CRT monitor.
- **Viewing Angle:** CRT can be viewed at almost any angle but LCD is best viewed head on. Even when viewing an LCD head on, narrow viewing angles can appear to have inconsistent colour and brightness.
- **Viewing Area:** The viewing area of a CRT is usually less than its advertised area. Most 19-inch CRT monitors, for example, typically have about 18 inches of viewable area. However, the LCD monitors are measured exactly, that is, if a LCD monitor is advertised as 17.4 inch, it is the same.
- **Cost:** Prices for LCD screens are quite high but they are coming down. They are still much more costlier than CRT.

2.3.4 Voice Response System

Previously, we discussed that voice (in speech recognition) can be taken as an input by the computer system. Similarly, the computer can also give output in the form of audio. Voice response system has an audio-response device which produces audio output. These sounds are pre-recorded in a computer system. Each sound

has a unique code. Whenever an enquiry is sought from the system, the computer responds in digital form which is sent to voice devices that unscramble the digital information and produces sound messages to the requesting computer.

There are two basic approaches to get a computer to talk to the user. The first is synthesis by analysis, in which the device analyses the input of an actual human voice speaking words, stores and processes the spoken sounds, and reproduce them as needed. The process of storing words is similar to the digitizing process we discussed while considering voice input. In essence, synthesis by analysis uses the computer as a digital tape recorder. The second approach to synthesizing speech is synthesis by rule, in which the device applies a complex set of linguistic rules to create artificial speech. Synthesis based on the human voice has the advantage of sounding more natural but is limited to the number of words stored in the computer.

The standard computer system can provide audio output with the addition of two components: a speech synthesizer that does the speaking and a screen reading software that tells the synthesizer what to say (see Figure 2.28). The synthesizer can be a computer card inserted into the computer or software that works with the computer's sound card. Screen reader is a software program that allows the user to control the synthesizer so that he can access text, which is displayed on the computer monitor, with combinations of keystrokes. Some screen review softwares use the standard computer keyboard keys, some use the numeric keypad, and some use special external keypads. A visually impaired user can use a screen reader to read anything on the screen. The screen reading software can even notify a user about various computer messages that "pop up" on the monitor from time to time.

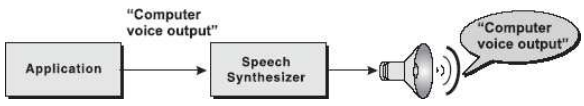

Figure 2.28: Audio Output

Voice output has become common in many places like airlines, bus terminals,

banks and brokerage houses. It is typically used when an inquiry is followed by a short reply (such as a bank balance or flight time). Many businesses have found other creative uses for voice output. For example, the telephone. Automatic telephone voices take surveys, inform customers that catalogue orders are ready to be picked up, and perhaps remind consumers that they have not paid their bills. Moreover, people with a total or partial speech handicap are faced with the problem of communicating their wishes and needs to others. Speech output systems are a valuable aid in this case.

2.3.5 Electronic Whiteboard

Electronic whiteboard is an interactive presentation device that works electronically to display digital images, drawings and text in different colours. The whiteboard is generally mounted on the wall and is connected to a computer (through USB, serial port or wireless technology like Bluetooth) and projector. The projector projects the computer's desktop on the whiteboard and user can interact with it using electromagnetic pens, fingers or other pointing devices (see Figure 2.29). The electromagnetic pens can be configured to any Figure 2.29 Electronic Whiteboard colour or width.

Figure 2.29: Electronic Whiteboard

A user can activate programs, applications and menus as well as enter text using either the on-screen keyboard or handwriting recognition utility. Nowadays, most whiteboards come with software that provides various tools and features to create

virtual versions of paper flipcharts with pen, highlighter, etc., enhancing the use of electronic whiteboard to a great extent. Electronic whiteboard is widely used for various purposes such as to display presentations, for teaching in classrooms, in corporate meetings, professional sports coaching and so on.

An interactive electronic whiteboard can be classified into one of the following categories:

- **Touch-based Whiteboard**
- **Pen-based Whiteboard**
- **Wii Remote, IR Pen-based Whiteboard**

Note: The device driver software installed on the computer enables the whiteboard to act as a *human input device* (HID), just like a mouse, to help the user with easy interaction.

2.3.6 Headphone and Headset

Headphone is an audio device equipped with a pair of speakers attached to a head-strap worn by the users. Headphones are used with almost all electronic devices such as portable computers, CD/DVD players, mp3 players, iPod, etc. They comprise high-quality speakers, are light in weight and very comfortable to wear. They can be easily connected to a computer via a mini stereo plug.

The headphones allow the users to listen only; however, some applications like live chats, videoconferencing and telecalling services demand the user to also speak at the same time. For such applications, a headset is used instead of a headphone. A headset is a combination of one or two speakers and a Figure 4.54 Headphone and Headset microphone with both the speaker and the microphone attached to a headstrap. The speaker(s) allows the person to hear the conversation and the

microphone allows the user to communicate with the person on the other end (see Figure 2.30).

Figure 2.30: Headphone and Headset

2.4 Computer Terminals

A computer terminal is a special unit that can perform both input and output. A terminal is an I/O device that uses a keyboard for input and a monitor for output. Due to this reason, a terminal is also known as video display terminal (VDT). Terminals can be categorized into the following types:

- **Dumb Terminal:** It refers to a terminal that has no processing or programming capabilities. It is designed to communicate exclusively with a host computer. Usually, it consists of a screen and keyboard used to access a host computer. It has electronics circuitry enough to interpret incoming instructions from the host computer, to display characters on the screen, to interpret keystrokes on the keyboard and pass them on to the host computer. Generally, dumb terminals are used for simple data entry or retrieval tasks. An example of a dumb terminal is one used by airline clerks at airport ticket and check-in counters.
- **Smart Terminal:** A smart terminal has built-in processing capability and memory but does not have its own storage capacity. In comparison to the dumb terminal, a smart terminal can communicate, retrieve data and can perform a limited processing of its own, that is, editing or verifcation of data. However, this kind of terminal cannot be used for programming. They

are often found in local area networks in offices.

- **Intelligent Terminal:** An intelligent terminal has memory and inbuilt microprocessors, thus also known as user-programmable terminal. This terminal can independently perform a certain number of jobs without even interacting with the mainframe. Although they are intelligent terminals, some workstations are designed without disk drives. Due to this, restricted data cannot be downloaded or copied.