2

Components of the Computer System

Key concepts

- **Hardware**
  - Processor
  - Motherboard
  - Peripherals and ports
  - Memory (Primary memory, Secondary memory)
  - Input / output devices
- **e-Waste**
- **Green computing**
- **Software**
  - System software (Operating system, Language processors, Utility software)
  - Application software (General purpose, Specific purpose)
  - Free and open source software concepts
  - Freeware and Shareware
- **Humanware / Liveware**

We are familiar with computers and their uses today. Computer can be defined as a fast electronic device that accepts data, processes it as per stored instructions and produces information as output. This chapter presents an overview of the basic design of a computer system: how the different parts of a computer system are organised and various operations are performed to do a specific task. We know that a computer has two major components - hardware and software. Hardware refers to all physical components associated with a computer system while software is a set of instructions for the hardware to perform a specific task. When we use computers to solve any problem in real life situations, the tasks are usually set up to process data to generate information. This chapter presents the various hardware components followed by electronic waste, its disposal methods and the concept of green-computing. Different classifications of software are also dealt with. We also discuss the concepts of free and open source, freeware, shareware and proprietary software.

2.1 Hardware

We know that a computer system consists of hardware and software. The term hardware represents the tangible and visible parts of a

computer, which consists of some electromechanical components. These hardware components are associated with the functional units of a computer. Let us discuss some of these components.

2.1.1 Processors

Fig. 2.1 : Central Processing Units

In high school classes we learned that the Central Processing Unit (CPU) / processor is responsible for all computing and decision making operations and coordinates the working of a computer. The performance of a CPU determines the overall performance of the computer (refer Figure 2.1). Since CPU is an Integrated Circuit (IC) package which contains millions of transistors and other components fabricated into a single silicon chip, it is also referred as microprocessor. A CPU is usually plugged into a large socket on the main circuit board (the motherboard) of the computer. Since heat is generated when the CPU works, a proper cooling system is provided with a heat sink and fan. Intel core i3, core i5, core i7, AMD Quadcore, etc. are some examples of processors.

Every computer contains an internal clock that regulates the rate at which instructions are executed. The CPU requires a fixed number of clock ticks (or clock cycles) to execute each instruction. The faster the clock, the more instructions the CPU can execute per second. Another factor is the architecture of the chip. The number of bits a processor can process at one time is called word size. Processors with many different word sizes exist: 8-bit, 16-bit, 32-bit, 64-bit, etc.

Registers are storage locations inside CPU, whose contents can be accessed more quickly by the CPU than other memory. They are temporary storage areas for instructions or data. They are not a part of memory; rather they are special additional storage locations that offer computers the advantage of speed. Registers work under the direction of the control unit to accept, hold, and transfer instructions or data and perform arithmetic or logical operations at high speed. It speeds up the execution of programs.

Important registers inside a CPU are:

a. **Accumulator:** The accumulator is a part of the Arithmetic Logic Unit (ALU). This register is used to store data to perform arithmetic and logical operation. The result of an operation is stored in the accumulator.

b. **Memory Address Register (MAR):** It stores the address of a memory location to which data is either to be read or written by the processor.

c. **Memory Buffer Register (MBR):** It holds the data, either to be written to or read from the memory by the processor.

d. **Instruction Register (IR):** The instructions to be executed by the processor are stored in the instruction register.

e. **Program Counter (PC):** It holds the address of the next instruction to be executed by the processor.

2.1.2 Motherboard

A motherboard is a large Printed Circuit Board (PCB) to which all the major components including the processor are integrated. Figure 2.2 shows the motherboard and its components. It also provides expansion slots for adding additional circuit boards like memory, graphics card, sound card, etc. The motherboard must be compatible with the processor chosen.

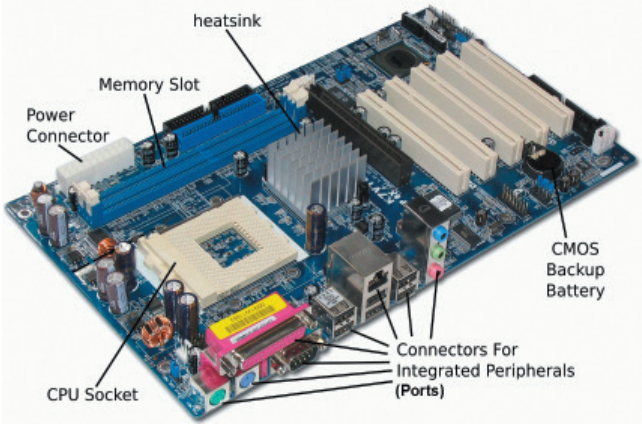

Fig. 2.2 : Motherboard

2.1.3 Peripherals and ports

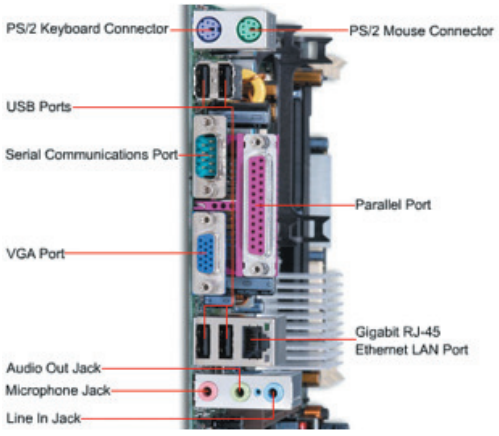

Fig. 2.3 : Ports

Peripherals are devices that are attached to a computer system to enhance its capabilities. Ports on the motherboard are used to connect external devices. Figure 2.3 shows the various ports in a computer system. Peripherals include input devices, output devices, external storage and communication devices. Peripheral devices communicate with the motherboard, through the ports available on the motherboard like Video Graphics Array (VGA), IBM Personal System/2 (PS/2), Universal Serial Bus (USB), Ethernet, High Definition Multimedia Interface (HDMI), etc. Let us look at some kinds of ports used on personal computers.

a. Serial port

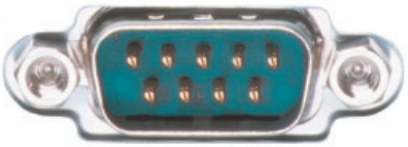

Fig 2.4: Serial port

A serial port / serial communication port transmits data one bit at a time. In older computers devices such as modem, mouse or keyboard were connected through serial ports (refer Figure 2.4). Serial cables are cheaper to make and easier to shield from interference. Since its speed is too low, they are being replaced by faster ports like PS/2, USB, etc.

b. Parallel port

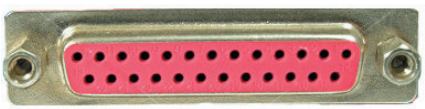

Fig. 2.5 : Parallel port

Parallel ports can transmit several bits of data simultaneously. It is faster than serial port and is used to connect a printer or scanner to the computer. Figure 2.5 shows a parallel port in a computer system.

c. USB port

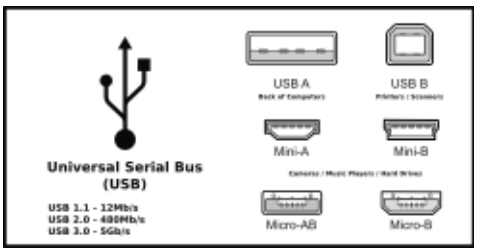

Fig. 2.6: USB ports

USB (Universal Serial Bus) is a connection that provides high speed data communication between devices. Due to its high bandwidth data transfer is faster. It is used for short-distance communication. USB port is used for connecting devices like keyboard, mouse, printer, scanner, flash drive, external hard disk, etc. Figure 2.6 shows the various types of USB ports. The main advantage of USB ports are:

- USB ports are capable of supplying electric power to external devices. This technology led to the development of devices like external hard disk, flash drive, dongle, etc. which draw power from the USB port. It can also be used for power devices like mobile phones, tablets, laptops, etc.
- USB devices can be connected and disconnected even when the power is on .

d. LAN port

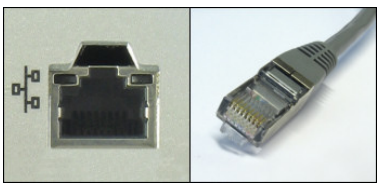

Fig. 2.7 : LAN port and RJ45 connector

Alternatively referred to as an Ethernet port, network connection, and network port, the Local Area Network (LAN) port is a port connection that allows a computer to connect to a network using a wired connection. The registered jack RJ45 is a standard type of connector used for connecting cables through LAN ports (refer Figure 2.7).

e. PS/2 port

Personal System/2 (PS/2) ports are special ports invented by IBM (International Business Machines) for connecting the keyboard and mouse (refer Figure 2.8). These types of ports are too slow and replaced by faster ports like USB nowadays.

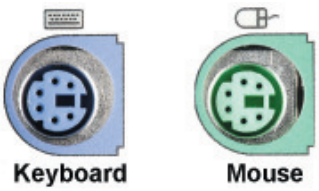

Fig. 2.8: PS/2 port

f. Audio ports

Audio ports are used to connect audio devices like speakers, microphone, etc. The three small connectors shown in Figure 2.9 are used for connecting:

a. Line in - Sound input (from any audio device like mobile line out, ipod, etc.)

b. Line out - Sound out (to connect your PC's sound output to external speakers)

c. Mic in - Microphone input port.

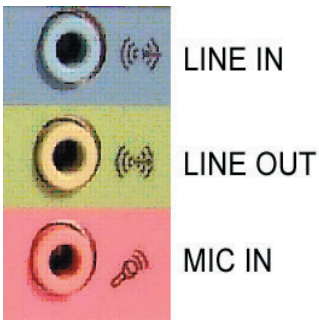

Fig. 2.9: Audio port

g. Video Graphics Array (VGA) port

VGA is a popular display standard developed by IBM. The VGA port is used to connect a monitor or a projector to a computer. The VGA connector has 15 pins displayed in three rows as indicated in Figure 2.10. Super VGA (SVGA) was developed to support 800 × 600 resolution and was later replaced by Extended Graphics Array (XGA) that supports 1024 by 768 resolution. Regardless of what resolution a monitor is able to support, they are commonly referred to as VGA.

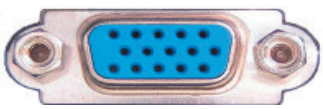

Fig. 2.10 : VGA port

h. High Definition Multimedia Interface (HDMI)

HDMI is a type of digital connection capable of transmitting high-definition video and multi channel audio over a single cable (refer Figure 2.11). To do the same thing with analog cables, we need to connect several video and audio cables.

Fig. 2.11 : HDMI port

2.1.4 Memory

Memory is a place where we can store data, instructions and results temporarily or permanently. Memory can be classified into two: primary memory and secondary memory. Primary memory holds data, intermediate results and results of ongoing jobs temporarily. Secondary memory on the other hand holds data and information permanently. Before learning more about memory, let us discuss the different memory measuring units.

Binary Digit	=	1 Bit	1 MB (Mega Byte)	=	1024 KB
1 Nibble	=	4 Bits	1 GB (Giga Byte)	=	1024 MB
1 Byte	=	8 Bits	1 TB (Tera Byte)	=	1024 GB
1 KB (Kilo Byte)	=	1024 Bytes	1 PB (Peta Byte)	=	1024 TB

a. Primary storage

Primary memory is a semiconductor memory that is accessed directly by the CPU. It is capable of sending and receiving data at high speed. This includes mainly three types of memory such as RAM, ROM and Cache memory.

i. Random Access Memory (RAM)

RAM refers to the main memory that microprocessor can read from and write to. Data can be stored and retrieved at random from anywhere within the RAM, no matter where the data is. Data or instructions to be processed by the CPU must be placed in the RAM (refer Figure 2.12). The contents of RAM are lost when power is switched off. Therefore, RAM is a volatile memory. The storage capacity of RAM is 2 GB and above

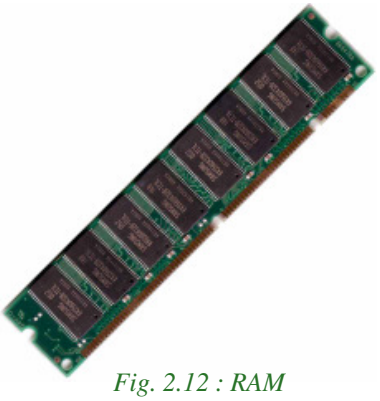

Fig. 2.12 : RAM

The speed of a RAM refers to how fast the data in memory is accessed. It is measured in Mega Hertz (MHz). When a computer is in use, its RAM contains the following:

1. The operating system software.
2. The application software currently being used.
3. Any data that is being processed.

ii. Read Only Memory (ROM)

ROM is a permanent memory that can perform only read operations and its contents cannot be easily altered. ROM is non-volatile; the contents are retained even after the power is switched off. ROM is used in most computers to hold a small, special piece of 'boot up' program known as Basic Input Output System (BIOS).This software runs when the computer is switched on or 'boots up'. It checks the computer's hardware and then loads the operating system. It is slower than RAM. Figure 2.13 shows a typical ROM chip.

Fig. 2.13 : ROM chip

There are some modified types of ROM that include:

1. **PROM** - Programmable ROM which can be programmed only once. PROMs are programmed at the time of manufacture.
2. **EPROM** - Erasable Programmable ROM that can be erased using ultra violet radiation and can be programmed using special electronic circuits.
3. **EEPROM** - Electrically Erasable Programmable ROM which can be erased and rewritten electrically.

Table 2.1 shows the comparison between RAM and ROM.

RAM	ROM
• It is faster than ROM • It stores the operating system, application programs and data when the computer is functioning. • It allows reading and writing. • It is volatile, i.e. its contents are lost when the device is powered off.	• It is a slower memory • It stores the program required to boot the computer initially • Usually allows reading only. • It is non-volatile, i.e. its contents are retained even when the device is powered off.

Table 2.1 : Comparison of RAM and ROM

iii. Cache memory

Cache memory is a small and fast memory between the processor and RAM (main memory). Frequently accessed data, instructions, intermediate results, etc. are stored in cache memory for quick access. When the processor needs to read from or write to a location in RAM, it first checks whether a copy of that data is in the cache. If so, the processor immediately reads the cache, which is much faster than reading from RAM. Cache is more expensive than RAM, but it is worth using it in order to maximise system performance. Commonly used cache memories and their capacities are Level 1 Cache (128 KB), Level 2 Cache (1 MB), Level 3 Cache (8 MB) and Level 4 Cache (128 MB).

b. Secondary or Auxiliary memory

Secondary memory is of permanent nature. Unlike the contents of RAM, the data stored in these devices does not vanish when power is turned off. Secondary memory is much larger in size than RAM, but is slower. It stores programs and data but the processor cannot access them directly. Secondary memory is also used for transferring data or programs from one computer to another. It also acts as a backup. The major categories of storage devices are magnetic, optical and semiconductor memory.

i. Magnetic storage devices

Magnetic storage devices use plastic tape or metal/plastic disks coated with magnetic materials. Data is recorded magnetically in these devices. Read/write heads are used to access data from these devices. Some of the popular magnetic storage devices are magnetic tapes, floppy disks, hard disks, etc.

Magnetic Tape

Magnetic tape is a backup device that can store huge volume of data. The cost per unit volume of a magnetic tape is less compared to other magnetic storage devices.

It is a recording medium consisting of a thin tape with a coating of fine magnetic material. It can be used for recording analog or digital data. Data is stored in frames across the width of the tape with a read/write head. The frames are grouped into blocks or records which are separated from other blocks by gaps as shown in Figure 2.14.

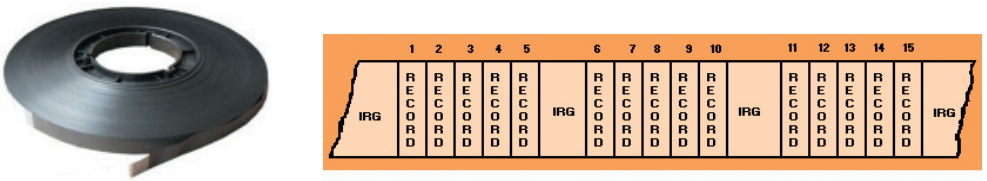

Fig. 2.14 : Magnetic Tape and Blocks of data on tape

It takes a lot of time to locate data in a magnetic tape, as it is a sequential access medium, similar to an audio cassette. For example, if we need to access the 100th record on the tape, we must first move through the previous 99 records. The capacity of tape media is referred in Terabytes.

Hard disk

The hard disk consists of metal disks coated with magnetic material concealed in dust free containers. Hard disks have very high storage capacity, high data transfer rates and low access time. It is more durable and less error prone. It is the most common secondary storage device used in computers.

A hard disk may contain one or more platters. Each platter requires two read/write heads, one for each surface. A tiny electromagnetic read/write head attached to an access arm magnetises tiny spots on the disk to store data as shown in Figure 2.15. The same electromagnetic head can later sense the magnetic fields of the spots, allowing the data to be read back from the disk.

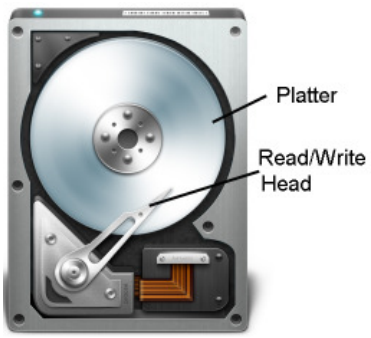

Fig. 2.15 : Hard disk

Data is stored on the surface of a platter in sectors and tracks. Tracks are concentric circles on a platter and a sector is a pie-sliced part of a disk platter as shown in Figure 2.16. Formatting is the activity of creating sectors and tracks on the disk. Only then can read/write operation be performed on the disk. If a disk having data is formatted, then all data will be lost.

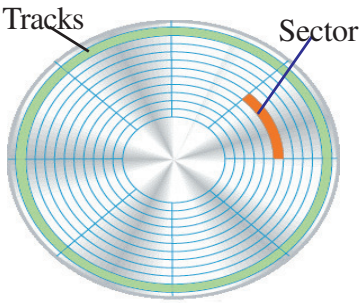

Fig. 2.16 : A platter

Large disks can be partitioned logically into distinct sections or volumes. These volumes are independent of each other and can be formatted independently.

Rating of Hard Disk Drive (HDD) depends on capacity, speed and access time

Storage capacity	:	500GB, 1TB or more
Speed	:	How fast the disk spins, rotations per minute (rpm) usually 5400 rpm/7200 rpm
Access time	:	Time to retrieve bits of data from disk (in milliseconds)

ii. Optical storage devices

Optical disk is a data storage medium which uses low-powered laser beam to read from and write data into it. It consists of an aluminum foil sandwiched between two circular plastic disks. Data is written on a single continuous spiral in the form of pits and lands as shown in Figure 2.17. The laser beam reads this pits and lands as 0s and 1s. It is very cheap to manufacture optical disks in large quantities and are a popular secondary storage medium. The main types of optical disks are CD, DVD and Blu-Ray.

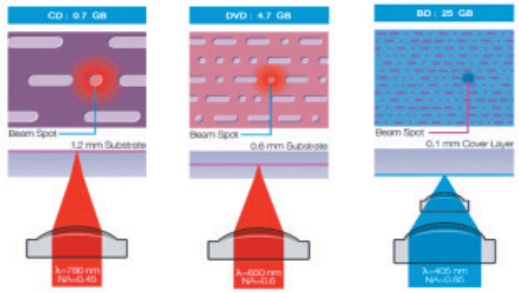

Fig. 2.17 : CD, DVD and Blu-ray disk - pits & lands

Compact Disk (CD)

Compact Disc is an optical storage medium capable of storing upto 700 MB of data. A CD drive uses red laser beams for reading from and writing data into CD. There are two types of CDs, CD-R and CD-RW. In CD-R (CD-Recordable) data can be written


Fig. 2.18 : CD

once and read many times where in CD-RW (CD-Rewritable) disks can be erased and rewritten at any time.

Digital Versatile Disk (DVD)

Digital Versatile Disk is an optical storage media similar to CD-ROM, but with a higher storage capacity. This is achieved by using smaller spots to record data. Recording and reading of data is done using DVD drive. Here also red laser beam is used for doing these operations. The capacity of a DVD varies from 4.37 GB to 15.9 GB. There are three major types of DVDs: DVD-ROM, DVD-RW and DVD-RAM.

DVD-ROM : DVD-Read Only Memory functions in the same way as CD-ROM

DVD-RW : DVD-Rewritable disks can be erased and rewritten at any time.

DVD-RAM : DVD Random Access Memory disks can be recorded and erased repeatedly. These are compatible only with devices manufactured by companies that support the DVD-RAM format. It is comparable to DVD-Rewritable disk, but have higher lifetime and can be erased more often than a DVD-RW.

A normal DVD known as DVD-5 stores 4.37 GB data where as a dual layer double side DVD known as DVD-18 can store 15.9 GB.

Blu-ray DVD

Blu-ray is an optical disk format developed to enable recording, rewriting and playback of High Definition (HD) video as well as storing huge amounts of data. CD and DVD technologies use red laser to read and write data while blu-ray format uses a blue-violet laser. Hence it has the name Blu-ray. The benefit of using a blue-violet laser is that it has a shorter wavelength than a red laser, which makes it possible to focus the laser spot with greater precision. This allows data to be packed more tightly. Therefore it is possible to store more data on the disk even though it is of the same size of a CD/DVD. The format offers more than five times the storage capacity of traditional DVDs and can hold up to 25 GB on a single-layer disc and 50 GB on a dual-layer disc.

iii. Semiconductor storage (Flash memory)

Flash drives use EEPROM chips for data storage. They do not contain any moving parts and hence they are shockproof. Flash memory is faster and durable when compared to other types of secondary memory. The different variants of flash memories are available today.

USB flash drive

A flash drive is a small external storage device, which consists of flash memory typically the size of a human thumb. USB flash drives are portable and rewritable. The storage capacity of a USB drive currently varies from 2 GB to 32 GB.

Fig. 2.19 : Flash drive

Flash memory cards

Flash memory card is another type of flash memory. They are flat and have a size of about 1 inch × 0.75 inch with a thickness of about 2 mm. Memory cards currently have storage capacities in the range of 1 GB - 32 GB. Flash memory cards also have a smaller version which is used within cell phones, tablets, etc (refer Figure 2.20). These smaller cards are about 6 mm × 3 mm in size and are less than 1 mm thick.

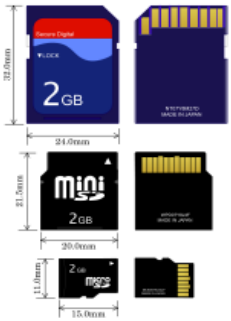

Fig. 2.20 : Flash memory cards

Role of different types of memories in computer

Let us discuss an example of data processing. Consider the case of a payroll program to calculate the salary of an employee. The data for all the employees is available in the hard disk. All the data about a particular employee is taken to the RAM and from there data related to salary calculation (bonus, deductions, etc.) is taken to the cache. The data representing the hours worked and the wages is moved to their respective registers. Using data on the hours worked and the wage, ALU makes calculations based on instructions from control unit. For further calculations, it moves the overtime hours, bonuses, etc. from cache to registers. As the CPU finishes calculations about one employee, the data about the next employee is brought from secondary storage into RAM, then cache and eventually into the registers.

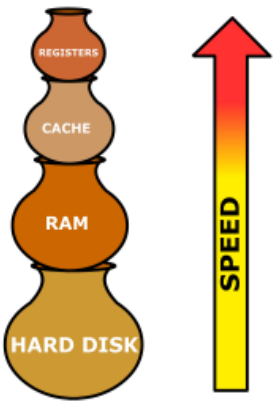

Fig. 2.21 : Memory hierarchy

Table 2.2 summarises the characteristics of the various kinds of data storage in the storage hierarchy. Modern computers are designed with this hierarchy due to the characteristics listed in the table.

To see how registers, primary memory and second storage work together, let us use the analogy of making a salad. In our kitchen we have:

- A refrigerator where we store vegetables for the salad.
- A counter where we place all vegetables before putting them on the cutting board for chopping.
- A cutting board on the counter where we chop vegetables.
- A recipe that details what vegetables to chop.
- The corners of the cutting board are kept free for partially chopped piles of vegetables that we intend to chop more or to mix with other partially chopped vegetables.
- A bowl on the counter where we mix and store the salad.
- Space in the refrigerator to put the mixed salad after it is made.

The process of making the salad is then: bring the vegetables from the fridge to the counter top; place some vegetables on the chopping board according to the recipe; chop the vegetables, possibly storing some partially chopped vegetables temporarily on the corners of the cutting board; place all the vegetables in the bowl and keep it back in the fridge if not served on the dinner table.

In this context the refrigerator serves as secondary (hard disk) storage. It can store high volumes of vegetables for long periods of time. The counter top functions like the computer's motherboard - everything is done on the counter (inside the computer). The cutting board is the ALU - the work gets done there. The recipe is the control unit - it tells you what to do on the cutting board (ALU). Space on the counter top is the equivalent of RAM - all required vegetables must be brought from the fridge and placed on the counter top for fast access. Note that the counter top (RAM) is faster to access than the fridge (disk), but cannot hold as much, and cannot hold it for long periods of time. The corners of the cutting board where we temporarily store partially chopped vegetables are equivalent to the registers. The corners of the cutting board are very fast to access for chopping, but cannot hold much. The salad bowl is like a cache memory, it is for storing chopped vegetables to be temporarily removed from the corners of the cutting board (as there is too much) or the salad waiting to be taken back to the fridge (putting data back on a disk) or to the dinner table (outputting the data to an output device).

Storage	Speed	Capacity	Relative Cost	Volatile
Registers	Fastest	Lowest	Highest	Yes
Cache	More Fast	Low	Very High	Yes
RAM/ROM	Very Fast	Low/Moderate	High	Yes
Hard Disk	Moderate	Very High	Very Low	No

Table 2.2 : Comparison of different types of memory

Check yourself

1. The fastest memory in a computer is _____.
2. The storage capacity of a single layer DVD is _____.
3. What is cache memory?
4. What is the use of program counter register?
5. What is HDMI?

2.1.5 Input/Output devices

The computer will be of no use unless it is able to communicate with the outside world. Input/output devices are required for users to communicate with the computer. In simple terms, input devices feed data and instructions into the computer and output devices present information from a computer system. These input/output devices are connected to the CPU through various ports or with the help of wireless technologies. Since they reside outside the CPU, they are called peripherals.

a. Input devices

An input device is used to feed data into a computer. It is also defined as a device that provides communication between the user and the computer. We will now discuss some input devices in detail.

i. Keyboard

Keyboard is the most common input device. It allows the user to input alphabets, numbers and other characters. Keyboard detects the key pressed and generates the corresponding ASCII code which can be recognised by the computer. The standard US keyboard introduced in 1986 has 101 keys. It has a keyboard layout called the

QWERTY design. QWERTY gets its name from the first six letters across in the upper-left-hand corner of the keyboard as shown in Figure 2.22.

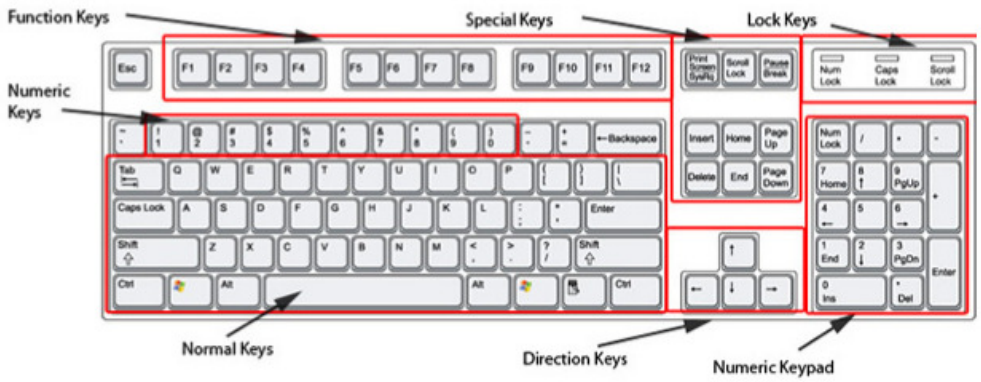

Fig. 2.22 : Keyboard

Keyboards can be classified as wired and wireless. Wired keyboards are connected to the CPU through a serial, PS/2 port or a USB port. Wireless keyboards are connected to the computer through infrared (IR), radio frequency (RF) or bluetooth connections. Portable flexible keyboards are also available now. New generation keyboards like laser keyboards that project the keyboard layout to any surface are being developed.

ii. Mouse

A mouse is a small hand-held device used to indicate the position of a cursor or its movement on a computer display screen by rolling it over a mouse pad / flat surface. A mouse has one or more buttons and possibly a scroll wheel. Scroll wheel is used for scrolling the screen vertically or horizontally. The different types of mouse are ball, optical and laser mouse. Ball mouse works on the principle of the movement of the ball, whereas optical mouse uses LED and laser mouses use laser beams for sensing the movement. Laser mouse has more precise movements when compared to other types of mouse. Wired mouse uses serial, PS/2 and USB ports to communicate, whereas a wireless mouse communicates with the computer via radio waves.

Fig. 2.23 : Mouse

iii. Light pen

A light pen is a pointing device shaped like a pen. The tip of the light pen contains a light-sensitive element which when placed against the screen, detects the light from the

screen enabling the computer to identify the location of the pen on the screen. Light pens have the advantage of 'drawing' directly onto the screen. They are used by engineers, artists, fashion designers for Computer Aided Designing (CAD) and drawing purposes.

Fig. 2.24 : Light Pen

iv. Touch screen

It is an input device that allows the user to operate by simply touching on the display screen. Some computers, tablets, smart phones, etc. have touch-sensitive display screens. It can also be operated using a stylus which gives more precision. Information kiosks at railway stations and bank ATMs also use touch screens as input device.

Fig. 2.25 : Touch screen

v. Graphic tablet

A graphics tablet consists of an electronic writing area and a special "pen" that works with it. Graphic tablet allows artists to create graphical images with motions and actions similar to traditional drawing tools. The pen of the graphics tablet is pressure sensitive. Hard or soft pressure on the tablet using the pen can result in brush strokes of different width in an appropriate graphics program.

Fig. 2.26 : Graphic tablet

vi. Touchpad

A touchpad is a pointing device found on the portable computers and some external keyboards. It allows us to move the mouse pointer without the need of an external mouse. Touchpad is operated by using finger and dragging it across the flat surface; as the finger moves on the surface, the mouse cursor will move in that same direction. The touchpad also has two buttons below the touch surface that enables to click.

Fig. 2.27 : Touchpad

vii. Joystick

Joystick is an input device used for playing video games, controlling training simulators and robots. Joysticks and other game controllers can also be used as pointing device. The joystick has a vertical stick which can move in any direction. It can be used to control

Fig. 2.28 : Joystick

objects in a video game or to make menu selections by the movement of a cursor displayed on the screen. It has a button on the top that is used to select the option pointed by the cursor.

viii. Microphone

A microphone can be attached to a computer to input sound. It accepts sound which is analogue in nature as input and converts it to digital format. The digitised sound can be stored in the computer for processing or playback. A computer loaded with speech recognition software like the one preinstalled in Windows 7, can convert what a person has said into text, which can be saved for word processing. A voice recognition program can process the input and convert it into machine-recognisable commands.

Fig. 2.29 : Microphone

ix. Scanner

Scanners can capture information, like pictures or text, and convert it into a digital format that can be edited using a computer. The quality of the image depends on the resolution of the scanner. The resolution of the image scanned is expressed in Dots Per Inch (DPI). The higher the DPI, the better the resolution.

The different variants of scanners are flat bed, sheet feed and hand held scanner. A sheet feed scanner can scan a single sheet, whereas flat bed can scan even from a book, but they are not portable. A hand held scanner is portable but the scanning action is not smooth as the scanner is moved manually.

Fig. 2.30 : Scanner

Optical Character Recognition (OCR) software is used to recognise the printed text in an image scanned and convert it into proper text format, which can be edited by a text editor. Advanced OCR system can read printed text in a large variety of fonts but has difficulty with hand written text. Accurate OCR SDK, Hindi OCR software, Akshara Malayalam OCR, etc. are examples of OCR softwares.

x. Optical Mark Reader (OMR)

OMR technology scans a printed form and reads predefined positions, and records the marks on the form. This technology is useful for applications in which large number of hand-filled forms need to be processed quickly with great accuracy, such as objective type tests and questionnaires.

Fig. 2.31 : Optical Mark Reader

OMR sheets are normaly use to evaluate multiple choice questions in competitive exams. It consists of bubble shaped options to mark answers. Candidates are required to darken the correct bubble option using a pen or pencil. OMR readers can recognise these marks and the appropriate software uses this input for evaluation (refer Figure 2.31). For accuracy of results, good quality paper and accurate alignment of printing is essential.

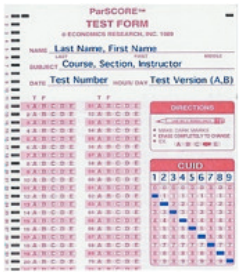

Fig. 2.32 : OMR sheet

xi. Barcode/Quick Response (QR) code reader

A barcode is a set of vertical lines of different thickness and spacing that represent a number. Barcode readers are devices that are used to input data from such set of barcodes (refer Figure 2.33). Hand-held scanners are commonly seen in shops to scan codes and price information for each of the items so that billing will be easier. Mobile phones with camera and special software can also be used as a barcode reader.

Fig. 2.33 : Barcode reader

A QR code is similar to barcodes. Barcodes are single dimensional whereas QR codes are two dimensional as shown in Figure 2.34. The two dimensional way of storing data allows QR code to store more data than a standard barcode. This code can store website URLs, plain text, phone numbers, email addresses and any other alphanumeric data. The QR code can be read using a barcode reader or a mobile phone with a camera and a special software installed.

Fig. 2.34 : QR Code

xii. Magnetic Ink Character Recognition (MICR) Reader

MICR readers are used in banks for faster electronic clearing of cheques. The lower portion of a cheque contains cheque number, branch code, bank code, etc. printed in a special font using an ink containing iron oxide particles as shown in Figure 2.35. Iron oxide has magnetic properties. MICR reader shown in Figure 2.36, can easily recognise these characters by magnetically charging them while scanning. This MICR data along with the image of the cheque is send to the cheque drawer's (the person who issues the cheque) branch to transfer the amount. This reduces errors in data entry and speeds up money transfer.

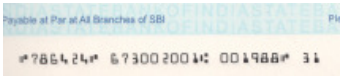

Fig. 2.35 : MIC Code

Fig. 2.36 : MICR Reader

xiii. Biometric sensor

A biometric sensor is a device that identifies unique human physical features with high accuracy. It is an essential component of a biometric system which uses physical features

like fingerprints, retina, iris patterns, etc., to identify, verify and authenticate the identity of the user. The three major types of biometric sensors are semiconductor sensor, optical sensor and ultrasound sensor. Figure 2.37 shows a finger print sensor.

Fig. 2.37: Biometric sensor

xiv. Smart card reader

A smart card is a plastic card that stores and transacts data. The data card may contain a memory or a microprocessor. Memory cards simply store data, while a microprocessor card, on the other hand, can add, delete and manipulate information in its memory. The smart card is used in most banking, healthcare, telephone calling, electronic cash payments and other applications.

Fig. 2.38: Smart card reader

Smart card readers are used to access data in a smart card. It can be contact type or contactless. A contact type of reader requires physical contact with the cards, which is made by inserting the card into the reader. A contactless type of reader works with a radio frequency that communicates when the card comes close to the reader. Many contactless readers are designed specifically for toll gate payment in transportation applications and person identity applications.

xv. Digital camera

A digital camera can take pictures and videos and convert them into digital format. Pictures or videos taken using a digital camera are stored inside its memory and can be transferred to a computer by connecting the camera to it.

Fig. 2.39 : Digital Camera

The quality of the lens, the density of Charge Couple Device (CCD), resolution (measured in megapixel), optical zoom and the software used in the camera determines the quality of the picture. Each picture is made up of thousands of tiny pixels (picture elements) and the camera stores the data about the color of each dot. The quality of the picture is determined by the number of pixels in each picture. Digital cameras have resolutions ranging from 2 mega pixel to 24 megapixels and optical zoom ranging from 3x to 60x.

Fig. 2.40 : Web Camera

Web camera is a compact and less expensive version of a digital camera. It is used in computers for video calling, video chatting, etc. It does not have an internal memory. Applications like Skype, Yahoo Messenger, etc. use webcam to capture images. Now, laptops also come with an inbuilt web camera.

b. Output devices

Output devices are devices that print/display output from a computer. Outputs generated by the output devices may be hardcopy output or softcopy output. Hardcopy outputs are permanent outputs which can be used at a later date or when required. They produce a permanent record on paper. The common output devices that produce hardcopy outputs are printers and plotters. Softcopy outputs are electronic and are available on the screen in a digital form. They do not produce a permanent record. A common softcopy output device is the Visual Display Unit (VDU).

i. Visual Display Unit (VDU)

A Visual Display Unit (VDU) is an output device that visually conveys text, graphics and video information. Information shown on a display device is called softcopy because the information exists electronically and is displayed for a temporary period of time. Display devices include Cathode Ray Tube (CRT) monitors, Liquid Crystal Display (LCD) monitors, Thin Film Transistor (TFT) monitors, Light Emitting Diode (LED) monitors, gas plasma monitors.

Some of the characteristics of a VDU are size, resolution, pixel-pitch and response time. VDUs are available in different sizes. The size of a monitor is measured diagonally across the screen, in inches. The resolution of the monitor is the maximum number of pixels it can display horizontally and vertically (such as 800×600 or 1024×768 or 1600×1200). The pixel spacing on the screen is called the dot pitch. A screen with smaller dot pitch produces sharper images. Response time refers to the time taken for a pixel to turn from a state of brightness to a state of darkness and then back again. Monitors, with lesser response time provide better movie viewing experience.

Cathode Ray Tube (CRT) monitor

The Cathode Ray Tube (CRT) monitor resembles television sets of the past. Two types of CRT monitors are available, monochrome and color. A monochrome monitor displays characters and images in a single colour on a dark background. Another variation of monochrome monitor capable of displaying different shades of grey is called a grey scale monitor. A colour monitor uses three different basic colours such as red, blue and green to display 16 to 1 million different colours. These monitors are preferred by some graphic artists for their accurate colour rendering and by some gamers for faster response to rapidly changing graphics.

Fig. 2.41: CRT monitor

Flat panel monitor

Flat panel displays are thinner, lighter in weight, consume less power and emit less heat compared to CRT monitors. Flat panel monitors are most commonly used in computers, especially in laptops. Different types of flat panel monitors are LCD Monitors, LED Monitors, Plasma Monitors and OLED Monitors.

Fig. 2.42: LCD monitor

Liquid Crystal Display (LCD) Monitors: LCD displays consists of liquid crystals sandwiched between two plastic plates. These crystals rearrange to form an image when an electric current is passed through them. A light source at the back of this plate makes the picture visible. This light source can be fluorescent lamp or LED.

Light Emitting Diode (LED) Monitors: LED monitors use LED directly behind the liquid crystal display (LCD) in order to light up the screen. This technique is very effective and gives each area of the screen its own light, which can be on or off. LED screens can produce massive contrast ratio making the difference between the lights and the blacks appear almost perfect. This technology is expensive. The advantage of using LED is better color quality, clarity, wider viewing angle, faster refresh rates and power savings.

Plasma Monitors: A flat-panel display consists of sandwiching neon/xenon gas between two sealed glass plates with parallel electrodes deposited on their surfaces. When a voltage pulse is passed between two electrodes, the gas lights up as different colours, creating images on a monitor. Plasma monitors provide high resolution but are expensive.

Organic Light Emitting Diode (OLED) Monitors: The panel of OLED is made up of millions of tiny LEDs. The O in OLED stands for organic, which means there is carbon in the light emitting layer of the panel. OLED screens are thinner and lighter than LCDs and LEDs. They can produce better quality images and have a better viewing angle. OLEDs consume less power, but are very expensive.

LCD projector

An LCD projector is a type of video projector for displaying video, images or computer data on a large screen or other flat surface. It is a modern equivalent of the slide projector or overhead projector. A beam of high-intensity light travels through thousands of shifting pixels in an LCD display. This beam of light then passes through a lens which projects and focuses the image on the surface.

Fig. 2.43 : LCD projector

ii. Printer

Printers are used to produce hardcopy output. Based on the technology used, they can be classified as impact or non-impact printers. Impact printers use the typewriting or printing mechanism where a hammer strikes the paper through a ribbon in order to produce output. Dot-matrix printers fall under this category. Non-impact printers do not touch the paper while printing. They use different technologies to print characters on paper. Inkjet, Laser and Thermal printers fall under this category of printers.

Two factors that determine the quality of a printer are its resolution and speed. Resolution is measured in terms of DPI. Speed is measured in terms of number of characters printed in a unit of time and is represented as characters per second (cps), lines per minute (lpm), or pages per minute (ppm).

Dot Matrix Printer (DMP)

Dot matrix printers use small electromagnetically activated pins in the print head and an inked ribbon, to produce images by impact. The most commonly used printer heads consists of 9 pins. Certain printers use 24 pins for better print quality. These printers are slow and noisy, and are not commonly used for personal use. The Dot Matrix Printers are widely used at cash counters in shops due to their low printing cost and for the reason that we get carbon copies from them.

Fig. 2.44: DMP Printer

Inkjet printer

Inkjet printers form the image on the page by spraying tiny droplets of ink from the print head. The printer needs several colours of ink (cyan, yellow, magenta and black) to make colour images. Some photo-quality ink jet printers have more colours of ink. Ink jet printers are inexpensive, but the cost of ink cartridges makes it a costly affair in the long run.

Fig. 2.45: Inkjet Printer

Laser printer

A laser printer produces good quality output. The image to be printed is transferred to a drum using a laser beam. The toner powder from the toner cartridge is then sprayed on the drum. The toner powder sticks onto the portions traced on the drum by the laser beam. It is transferred to a paper by rolling the paper over the drum. Through heating the powder is fused on to the paper.

Fig. 2.46: Laser printer

Monochrome and colour laser printers are available. Colour laser printers use multiple colour toner cartridges to produce colour output and are expensive. Laser printers are faster and their speed is rated in pages per minute (ppm).

Thermal printer

Thermal printing produces a printed image by selectively heating heat-sensitive thermal paper when it passes over the thermal print head. The coating turns black in the areas where it is heated, producing an image. Thermal printers print quiet and faster than dot matrix printers. They are also smaller, lighter and consume less power, making them ideal as portable printers. Thermal printers are popular as printers at Point-of-Sale terminals.

Fig. 2.47 : Thermal printer

Features	Laser Printers	Inkjet Printers	Thermal Printers	Dot Matrix Printers
Printing material used	Ink powder	Liquid ink	Heat sensitive paper	Ink soaked ribbon
How it prints?	It fuses the powder on the paper through heating.	It sprays liquid ink on paper through microscopic nozzles.	Thermal paper is passed over the thermal print head.	Pins are pushed against ribbon on paper.
Printing speed	20 pages per minute	6 pages per minute	150 mm per second	30 - 550 characters per second
Quality	Printing quality is good. Best for black and white.	Printing quality is good, especially for smaller fonts.	Poor quality printing of images. Good quality text printing.	Poor printing quality for images. In terms of text, printing is good.
Advantages	Quiet, prints faster, high print quality.	Quiet, high print quality, no warm up time, device cost is less.	Quiet, fast, smaller, lighter & consume less power. Portable.	Cheaper to print as ribbon is cheap. Carbon copy possible.
Disadvantages	More susceptible to paper jams. Toner is expensive. Device itself is expensive.	Ink is expensive, ink is not waterproof, and nozzle is prone to clogging.	Requires special thermal quality paper. Poor quality printing.	Initial purchase is expensive, maintenance is expensive, printing is not fast, makes noise.

Table 2.3 : Comparison of printers

iii. Plotter

A plotter is an output device used to produce hardcopies of graphs and designs on the paper. A plotter is typically used to print large-format graphs or maps such as construction maps, engineering drawings and big posters. It is used in the design of cars, ships, aircrafts, buildings, highways etc. Plotters are of two types: Drum plotters and Flatbed plotters.

Drum plotter

A drum plotter is also known as roller plotter. It consists of a drum or roller on which a paper is placed and the drum rotates back and forth to produce the graph on the paper. It also consists of a drawing arm that holds a set of coloured ink pens or pencils. The drawing arm moves side to side as the paper is rolled back and forth through the roller. In this way, a perfect graph or map is created on the paper.

Fig.2.48: Drum plotter

Flatbed plotter

A flatbed plotter is also known as table plotter. It plots on paper that is spread and fixed over a rectangular flatbed table. The flatbed plotter uses two drawing arms, each of which holds a set of coloured ink pens or pencils. The drawing arms move over the stationary paper and draw the graph on the paper. Flatbed plotter is very slow in drawing or printing graphs. The large and complicated drawing can take several hours to print.

Fig.2.49: Flatbed plotter

iv. Three dimensional (3D) printer

A 3D printer is a new generation output device used to print 3D objects. It can produce different kinds of objects in different materials, using the same printer. A 3D printer can print anything from ceramic cups to plastic toys, metal machine parts, stoneware vases, fancy chocolate cakes, etc.

The 3D printing process turns the object to be printed into thousands of horizontal tiny little layers. It then prints these layers from the bottom to top, layer by layer. These tiny layers stick together to form a solid object.

Fig.2.50: 3D Printer

v. Audio output device

The audio output is the ability of the computer to produce sound. Speakers are the output device that produces sound. It is connected to the computer through audio ports. The speaker produces sound by the movement of the diaphragm in the speaker, forward and backward according to the electrical signals coming out of the audio port. For high quality sound reproduction computers use 2.1 (3 speakers), 5.1 (5 speakers) and 7.1 (7 speakers) speaker systems.

Fig.2.51: Speakers

2.2 e-Waste

e-Waste refers to electronic products nearing the end of their "useful life". Electronic waste may be defined as discarded computers, office electronic equipment, entertainment devices, mobile phones, television sets and refrigerators. The used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered as e-Waste.

Nowadays electronics is part of modern life - desktops, laptops, cell phones, refrigerators, TVs and a growing number of other gadgets. Every year we buy new, updated equipments to satisfy our needs. More than 300 million computers and one billion cell phones are produced every year. All of these electronics goods become obsolete or unwanted, often within two or three years of purchase. This global mountain of waste is expected to continue growing at 8% per year.

Rapid changes in technology, changes in media, falling prices and planned obsolescence have resulted in a fast-growing surplus of electronic waste around the globe. It is estimated that 50 million tons of e-Waste are produced each year. Only 15-20% of e-Waste is recycled, the rest of these materials go directly into landfills and incinerators. Sale of electronic products in countries such as India and China and across continents such as Africa and Latin America are set to rise sharply over the next 10 years.

2.2.1 Why should we be concerned about e-Waste?

Electronic waste is not just waste. It contains some toxic substances such as mercury, lead, cadmium, brominated flame retardants, etc. The toxic materials can cause cancer, reproductive disorders and many other health problems, if not properly managed. It has been estimated that e-Waste may be responsible for upto 40% of the lead found in landfills.

Chemical	Source	Consequence
Lead	Found as solder on printed circuit boards and in computer monitor glass.	Lead can cause damage to the central and peripheral nervous systems, blood systems, and kidneys in humans.
Mercury	Found in printed circuit boards, LCD screen backlights.	Affect a baby's growing brain and nervous system. Adults can suffer organ damage, mental impairment and a variety of other symptoms.
Cadmium	Found in chip resistors and semiconductors.	Cause various types of cancer. Cadmium can also accumulate in, and harm the kidneys.
BFRs-Brominated Flame Retardants	Found in printed circuit boards and some plastics.	These toxins may increase the risk of cancer.

Table 2.4 : Hazardous chemicals, its source and consequence

2.2.2 What happens to the e-Waste?

Unfortunately, an incredibly small percentage of e-Waste is recycled. Even when we take it to a recycling center it is often not actually recycled - in the way most of us expect.

CRTs have a relatively high concentration of lead and phosphors both of which are necessary for the display. The United States Environmental Protection Agency (EPA) included discarded CRT monitors in its category of 'hazardous household waste'.

The majority of e-Waste is most often dumped or burned - either in formal landfills and incinerators or informally dumped or burned. These inappropriate disposal methods for electronic waste fail to reclaim valuable materials or manage the toxic materials safely. In effect, our soil, water and air are easily contaminated.

Fig. 2.52: Defective and obsolete electronic items

e-Waste should never be disposed with garbage and other household wastes. This should be segregated at the site and sold or donated to various organisations. Considering the severity of the e-Waste problem, it is necessary that certain

management options be adopted by government, industries and the public to handle the bulk e-Waste.

Realising the growing concern over e-Waste, Central Pollution Control Board (CPCB) of Government of India has formulated "The e-Waste (Management & Handling) Rules, 2011" and are effective from 01-05-2012. These rules shall apply to every producer, consumer, collection centre, dismantler and recycler of e-Waste involved in the manufacture, sale and processing of electrical and electronic equipment or components. The implementation and monitoring of these guidelines shall be done by the State Pollution Control Boards concerned.

Government of Kerala has introduced strict measures for safe collection and disposal of e-Waste through a government order. The government has defined the role of manufacturers, local bodies and the Pollution Control Board (PCB) in safe disposal of e-Waste. Under the Extended Producer Responsibility, manufacturers of electrical and electronic goods will be required to take back used products from consumers directly or through agents or introduce buyback arrangement. They will also have to supply the e-Waste to authorised recycling units. Consumers have been directed to return used products of known brands to the manufacturers or deposit them at the collection centresset up by local bodies.The PCB will be required to identify agencies for recycling or disposal of e-Waste and organise awareness programmes on e-Waste disposal.

2.2.3 e-Waste disposal methods

The following disposal methods can be used for disposing e-Waste.

a. **Reuse:** It refers to second-hand use or usage after the equipment has been upgraded or modified. Most of the old computers are passed on to relatives/ friends or returned to retailers for exchange or for money. Some computers are also passed on to charitable institutions, educational institutions, etc. Inkjet cartridges and laser toners are also used after refilling. This method reduces the volume of e-Waste generation.

b. **Incineration:** It is a controlled and complete combustion process in which the waste is burned in specially designed incinerators at a high temperature in the range of 900 to 1000 degree Celsius.

c. **Recycling of e-Waste:** Recycling is the process of making or manufacturing new products from a product that has originally served its purpose. Monitors, keyboards, laptops, modems, telephone boards, hard drives, compact disks, mobiles, fax machines, printers, CPUs, memory chips, connecting wires and cables can be recycled.

d. **Land filling:** It is one of the most widely used, but not recommended methods for disposal of e-Waste. In this method soil is excavated from the trenches made and waste material is buried in it, which is covered by a thick layer of soil.

2.2.4 Students' role in e-Waste disposal

- Stop buying unnecessary electronic equipments.
- When electronic equipments get faulty try to repair it instead of buying a new one.
- Try to recycle electronic equipments by selling them or donating them to others extending their useful life and keeping them out of the waste stream.
- If you really need to buy new electronics, choose items with less hazardous substances, greater recycled content, higher energy efficiency, longer life span, and those that will produce less waste.
- Visit the manufacturer's website or call the dealer to find out if they have a take back programme or scheme for your discarded electronics.
- If the device is battery-operated, buy rechargeable instead of disposable batteries.
- Buy products with good warranty and take back policies.

2.3 Green computing or Green IT

Green computing is the study and practice of environmentally sustainable computing or IT. Green computing is the designing, manufacturing, using and disposing of computers and associated components such as monitors, printers, storage devices, etc., efficiently and effectively with minimal or no impact on the environment.

One of the earliest initiatives towards green computing was the voluntary labelling program known as 'Energy Star'. It was conceived by the Environmental Protection Agency (EPA) in 1992 to promote energy efficiency in hardware of all kinds. The Energy Star label has become a common sight, especially in notebook computers and displays. Similar programmes have been adopted in Europe and Asia. The commonly accepted Energy Star symbol is shown in Figure 2.53.

Fig.2.53: Energy Star label

Government regulation is only a part of an overall green computing idea. The work habits of computer users and businesses have to be modified to minimise adverse impact on the global environment. Here are some steps that can be taken:

- Turn off computer when not in use.
- Power-on the peripherals such as laser printers only when needed
- Use power saver mode.
- Use laptop computers rather than desktop computers whenever possible.
- Take printouts only if necessary.

- Use Liquid Crystal Display (LCD) monitors rather than Cathode Ray Tube (CRT) monitors.
- Use hardware/software with Energy Star label.
- Dispose e-Waste according to central, state and local regulations.
- Employ alternative energy sources like solar energy.

The environmentally responsible and eco-friendly use of computers and their resources is known as green computing.

How to make computers green?

The features that are important in making a computer greener include size, efficiency and materials. Smaller computers are greener because they use fewer materials and require less electricity to run. Efficient use of energy is also an important component of a green computer. Smaller computers such as laptops are more energy-efficient than bigger models and LCD screens use much less energy than the older CRT models. The use of hazardous materials such as lead and mercury should be minimised.

To promote green computing the following four complementary approaches are employed:

Green design: Designing energy-efficient and eco-friendly computers, servers, printers, projectors and other digital devices.

Green manufacturing: Minimising waste during the manufacturing of computers and other components to reduce the environmental impact of these activities.

Green use: Minimising the electricity consumption of computers and peripheral devices and using them in an eco-friendly manner.

Green disposal: Reconstructing used computers or appropriately disposing off or recycling unwanted electronic equipment.

Check yourself

1. The environmentally responsible and eco-friendly use of computers and their resources is known as _____ .
2. The process of making or manufacturing new products from the product that has originally served its purpose is called _____.
3. Compare dot matrix printers and laser printers.
4. List any two input and output devices each.

Let us do

1. *Conduct a survey in your locality to study the impact of e-Waste on the environment and health of the people and write a report.*
2. *Discuss the importance of green computing.*

2.4 Software

Software is a general term used to denote a set of programs that help us to use computer system and other electronic devices efficiently and effectively. If hardware is said to form the body of a computer system, software is its mind.

There are two types of software:

- System software
- Application software

2.4.1 System software

It is a set of one or more programs designed to control the operations of a computer. They are general programs designed to assist humans in the use of computer system by performing tasks such as controlling the operations, move data into and out of a computer system and to do all the steps in executing application programs. In short, system software supports the running of other software, its communication with other peripheral devices. It helps the users to use computer in an effective manner. It implies that system software helps to manage resources of the computer. Figure 2.53 depicts how system software interfaces with user and hardware.

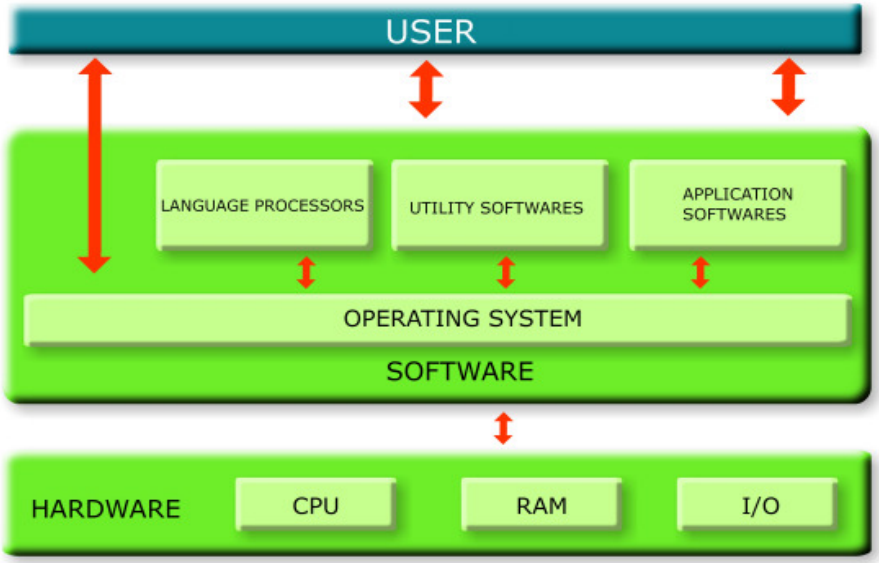

Fig. 2.54: Software with user and hardware interface

System software is a set of system programs which aids in the execution of a general user's computational requirements on a computer system. The following are the components of system software.

a. Operating system

b. Language processors

c. Utility software

a. Operating system

Operating system is a set of programs that acts as an interface between the user and computer hardware. The primary objective of an operating system is to make the computer system convenient to use. Operating system provides an environment for user to execute programs. It also helps to use the computer hardware in an efficient manner.

Operating system controls and co-ordinates the operations of a computer. It acts as the resource manager of the computer system. Operating system is the most important system software. It is the first program to be loaded from hard disk in the computer and it resides in the memory till the system is shut down. It tries to prevent errors and the improper use of computer.

Major functions of an operating system

The major functions of an Operating System are process management, memory management, file management, security management and command interpretation.

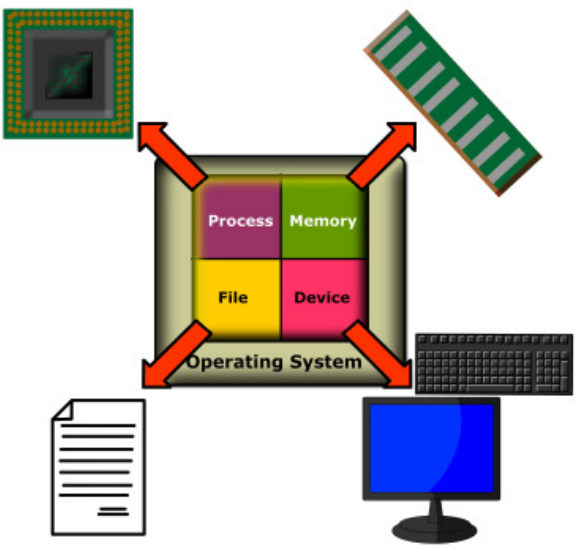

Fig. 2.55: Operating System as a resource manager

i. Process management

By the term process we mean a program in execution. The process management module of an operating system takes care of the allocation and de-allocation of processes and scheduling of various system resources to the different requesting processes.

ii. Memory management

Memory management is the functionality of an operating system which handles or manages primary memory. It keeps track of each and every memory location to ensure whether it is allocated to some process or free. It calculates how much memory is to be allocated to each process and allocates it. It de-allocates memory if it is not needed further.

iii. File management

The file management module of an operating system takes care of file related activities such as organising, naming, storing, retrieving, sharing, protection and recovery.

iv. Device management

Device management module of an operating system performs the management of devices attached to the computer. It handles the devices by combining both hardware and software techniques. The OS communicates with the hardware device via the device driver software.

Examples of various operating systems are DOS, Windows, Unix, Linux, Mac OS X, etc.

b. Language processors

We know that natural languages are the medium of communication among human beings. Similarly, in order to communicate with the computer, the user also needs to have a language that should be understood by the computer. Computer languages may be broadly classified into low level languages and high level languages.

Low-level languages are described as machine-oriented languages. In these languages, programs are written using the memory and registers available on the computer. Since the architecture of computer differs from one machine to another, there is separate low level programming language for each type of computer. Machine language and assembly language are the different low level languages.

Machine language: We know that a computer can understand only special signals, which are represented by 1s and 0s. These two digits are called binary digits. The language, which uses binary digits, is called machine language. Writing a program in machine language is definitely very difficult. It is not possible to memorise a long string of 0s and 1s for every instruction.

Assembly language: Assembly language is an intermediate-level programming language. Assembly languages use mnemonics. Mnemonic is a symbolic name given to an operation. For example ADD for addition operation, SUB for subtraction operation, etc. It is easier to write computer programs in assembly language as compared to machine language. It is machine dependent and programmer requires knowledge of computer architecture.

High Level Languages (HLL): These are like English languages and are simpler to understand than the assembly language or machine language. High level language is not understandable to the computer. A computer program written in a high level language is to be converted into its equivalent machine language program. So these languages require a language translator (compilers or interpreters) for conversion. Examples of high level programming languages are BASIC, C, C++, Java, etc.

Need for language processor

The programs consisting of instructions to the computer, written in assembly language or high level language are not understood by the computer. We need language processors to convert such programs into low level language, as computer can only understand machine language. Language processors are the system programs that translate programs written in high level language or assembly language into its equivalent machine language.

Types of language processors

- **Assembler:** Assembly languages require a translator known as assembler for translating the program code written in assembly language to machine language. Because computer can interpret only the machine code instruction, the program can be executed only after translating. Assembler is highly machine dependent.
- **Interpreter:** Interpreter is another kind of language processor that converts a HLL program into machine language line by line. If there is an error in one line, it reports and the execution of the program is terminated. It will continue the translation only after correcting the error. BASIC is an interpreted language.

- **Compiler:** Compiler is also a language processor that translates a program written in high level language into machine language. It scans the entire program in a single run. If there is any error in the program, the compiler provides a list of error messages along with the line number at the end of the compilation. If there are no syntax errors, the compiler will generate an object file. Translation using compiler is called compilation. After translation compilers are not required in memory to run the program. The programming languages that have a compiler are C, C++, Pascal, etc.

Figure 2.56 shows process involved in the translation of assembly language and high level language programs into machine language programs.

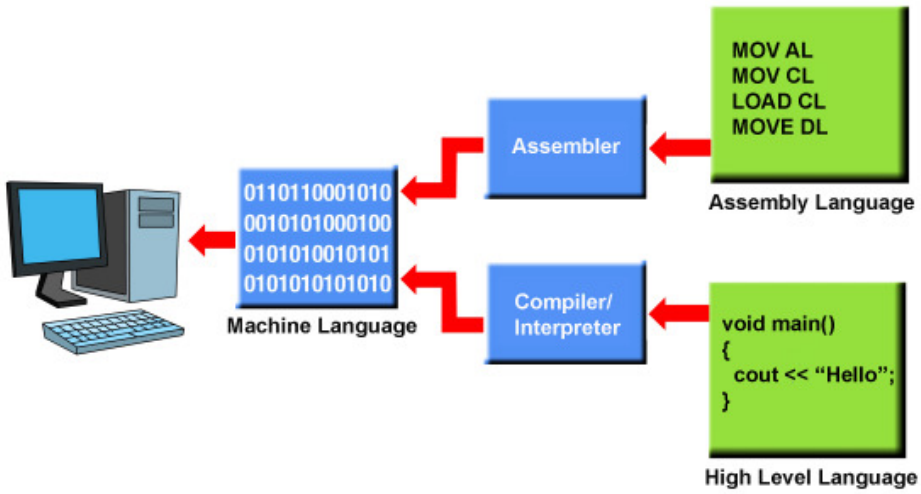

Fig. 2.56: Language processing

c. Utility software

Utility software is a set of programs which help users in system maintenance tasks and in performing tasks of routine nature. Some of the utility programs with their functions are listed below:

- **Compression tools:** Large files can be compressed so that they take less storage area. These compressed files can be decompressed into its original form when needed. Compression of files is known as zipping and decompression is called unzipping. WinZip, WinRAR, etc. are examples of compression tools.
- **Disk defragmenter:** Disk defragmenter is a program that rearranges files on a computer hard disk. The files are arranged in such a way that they are no longer fragmented. This enables the computer to work faster and more efficiently.

- **Backup software:** Backup means duplicating the disk information so that in an event of disk failure or in an event of accidental deletion, this backup may be used. Backup utility programs facilitates the backing up of disk.
- **Antivirus software:** A computer virus is a program that causes abnormality in the functioning of a computer. Antivirus software is a utility program that scans the computer system for viruses and removes them. As new viruses are released frequently, we have to make sure that latest antivirus versions are installed on the computer. Most of the antivirus programs provide an auto-update feature which enables the user to download profiles of new viruses so as to identify and inactivate them. Norton Antivirus, Kaspersky, etc. are examples of antivirus programs.

2.4.2 Application software

Software developed for specific application is called application software. It includes general purpose software packages and specific purpose software. GIMP, Payroll System, Airline Reservation System, Tally, etc. are examples of application software.

a. General purpose software packages

General purpose software are used to perform operations in a particular application area. Such software is developed keeping in mind the various requirements of its users. They provide a vast number of features for its users. General purpose software is classified as word processors, spreadsheet software, presentation software, database software and multimedia software.

- **Word processing software:** Word Processing software is designed for creating and modifying documents. It helps to create, edit, format and print textual matters easily. Formatting features include different font settings, paragraph settings, bullets and numbering, alignments and more. In addition to this it can check spelling and grammar in the document, insertion of pictures, charts and tables. We can specify headers and footers for every page in the document. The most popular examples of this type of software are MS Word, Open Office Writer, etc.
- **Spreadsheet software:** Spreadsheet software allows users to perform calculations using spreadsheets. They simulate paper worksheets by displaying multiple cells that make up a grid. It also allows us to insert drawing objects in the worksheet and create different types of charts for graphical representation of numerical data. Microsoft Excel, Open Office Calc, Lotus 1-2-3 and Apple Numbers are some examples of spreadsheet software.

- **Presentation software:** The software that is used to display information in the form of a slide show is known as presentation software. Presentation software allows preparing slides containing pictures, text, animation, video and sound effects. Microsoft PowerPoint and Open Office Impress are examples for presentation software.
- **Database software:** Database is an organised collection of data arranged in tabular form. Database Management System (DBMS) consists of a collection of interrelated data and a set of programs to access those data. The primary goal of a DBMS is to provide an environment that is both convenient and efficient to use in retrieving and storing database information. They provide privacy and security to data and enforce standards for data. Examples of DBMS software are Microsoft Access, Oracle, PostgreSQL, My SQL, etc.
- **Multimedia software:** Multimedia is the integration of multiple forms of media. This includes text, graphics, audio, video, etc. Multimedia software can process information in a number of media formats. It is capable of playing media files. Some multimedia software allows users to create and edit audio and video files. Audio converters, audio players, and video editing software are some forms of multimedia software. Examples are VLC Player, Adobe Flash, Real Player, Media Player, etc.

b. Specific purpose software

Specific purpose software is a highly specialised software designed to handle particular tasks. These are tailor-made software to satisfy the needs of an organisation or institution. It is also known as customised software. Since customised software is developed for a single customer, it can accommodate that customer's particular preferences and expectations. Some examples of specific purpose application software are listed in Table 2.5.

Application Software	Purpose
• Payroll System	• Payroll system maintains the details of employees of an organisation and keeps track of their salary details.
• Inventory Management System	• It is used for tracking inventory levels, orders, sales and deliveries in a business firm.
• Human Resource Management System	• It is used for managing human resource in an organisation.

Table 2.5 : Examples of Application Software

Check yourself

1. Define operating system.
2. Give two examples for OS.
3. A program in execution is called _____.
4. Mention any two functions of OS
5. Name the software that translates assembly language program into machine language program.
6. Differentiate between compiler and interpreter.
7. DBMS stands for _____.
8. Give two examples for customized software.
9. Duplicating disk information is called _____.

2.5 Free and open source software

Free and open source software gives the user the freedom to use, copy, distribute, examine, change and improve the software. Nowadays free and open source software is widely used throughout the world because of adaptable functionality, less overall costs, vendor independency, adherence to open standards, interoperability and security.

The Free Software Foundation (FSF) defines the four freedoms for free and open source software:

Freedom 0 - The freedom to run program for any purpose.

Freedom 1 - The freedom to study how the program works and adapt it to your needs. Access to source code should be provided.

Freedom 2 - The freedom to distribute copies of the software.

Freedom 3 - The freedom to improve the program and release your improvements to the public, so that the whole community benefits.

The following are some of the examples of free and open source software:

GNU/Linux: GNU/Linux is a computer operating system assembled under the model of free and open source software development and distribution. It was organised in the GNU project introduced in 1983 by Richard Stallman in the FSF.

GIMP: It stands for GNU Image Manipulation Program. It is an image editing software. It can be used for retouching photographs, creating and editing images. It supports graphic files of different formats and allows converting from one format to another.

Mozilla Firefox: It is one of the most popular web browsers created by the Mozilla Corporation. It provides added security features for safe browsing.

OpenOffice.org: It is a complete office suite that contains word processor (Writer) to prepare and format documents, spreadsheets (Calc) and presentations (Impress). It works on both Linux and Windows platforms.

2.6 Freeware and shareware

Freeware refers to copyrighted computer software which is made available for use free of charge for an unlimited period.

The term shareware refers to commercial software that is distributed on a trial basis. It is distributed without payment and with limited functionality. Shareware is commonly offered in a downloadable format on the Internet. The distribution of this kind of software aims at giving the users a chance to analyse the software before purchasing it. Some shareware works for a limited period of time only.

Table 2.6 highlights a comparison between freeware and shareware:

Freeware	Shareware
Freeware refers to software that anyone can download from the Internet and use for free.	Sharewares give users a chance to try the software before buying it.
All the features are free.	All features are not available. To use all the features of the software, user has to purchase it.
Freeware programs can be distributed free of cost.	Shareware may or may not be distributed freely. In many cases, author's permission is needed to distribute the shareware.

Table 2.6 : Comparison of Freeware and Shareware

Let us do

1. *Conduct a debate on free software and proprietary software.*
2. *Discuss four freedoms which make up a free software.*

2.7 Proprietary software

Proprietary software is a computer program that is an exclusive property of its developer or publisher and cannot be copied or distributed without licensing agreements. It is sold without any access to source code and is therefore not possible to change or improve by the user. Some examples of proprietary software are Microsoft Windows Operating System, MS Office, Mac OS, etc.

2.8 Humanware or Liveware

Humanware or liveware refers to humans who use computer. It was used in computer industry as early as 1966 to refer to computer users, often in humorous contexts by analogy with software and hardware. It refers to programmers, systems analysts, operating staff and other personnel working in a computer system (refer Table 2.7).

Humanware	Job Description
System Administrators	Upkeep, configuration and reliable operation of computer systems; especially multi-user computers such as servers.
Systems Managers	Ensure optimal level of customer services and maintain expertise in all business unit systems and develop professional relationships with all vendors and contractors.
System Analysts	Design new IT solutions to improve business efficiency and productivity.
Database Administrators	Create, monitor, analyse and implement database solutions.
Computer Engineers	Design either the hardware or software of a computer system.
Computer Programmers	Write the code that computers read in order to operate properly.
Computer Operators	Oversee the running of computer systems, ensuring that the machines are running, physically secured and free of any bugs.

Table 2.7 : Examples of Humanware

Check yourself

1. An example of free and open source software is _____.
2. The software that give users a chance to try it before buying is _____.
3. What do you mean by free and open source software?
4. An example of proprietary software is _____.
5. Give two examples of humanware.

Let us sum up

A computer system consists of hardware and software. Hardware refers to the visible and tangible parts of computer. Processor, motherboard, peripheral and ports, memory devices, input/output devices, etc. belong to hardware components of computer. Memory is classified into primary and secondary memories. Primary storage consists of RAM, ROM and cache. Seciondary storage devices are further classified into magnetic storage, optical storage and semi conductor storage devices. There are variety of input devices which include keyboard, mouse, light pen, touch screen, graphic tablet, touchpad, joystick, microphone, scanner, OMR, barcode reader, biometric sensor, smart card reader, digital camera, etc. Similarly, there are output devices like visual display units, printers, plotters, audio output devices, etc. The used electronics which are destined for reuse, resale, salvage, recycling or disposal are considered as e-Waste. There are different methods for e-Waste disposal which include re-use, incineration, recycling, land filling, etc. Green computing is the study and practice of environmentally sustainable computing or IT.

Software refers to the intangible or invisible part of the computer which is a set of programs that help us to use computer system and other electronic devices efficiently and effectively. Software is classified into system software and application software. System software include operating system, language processors and utility software. Application software is further divided into general purpose software and specific purpose software. Free and open source software are available which give freedom to use, copy, distribute, examine, change and improve the software. The term freeware refers to software that can be downloaded from the Internet and use for free. Shareware give users a chance to try the software before buying it. There is one more component associated with computer, the humanware. It refers to humans who use computer at various level.

Learning outcomes

After the completion of this chapter the learner will be able to

- explain the basic organisation of computer system.
- list the use of different types of input and output devices.
- distinguish between system software and application software.
- identify the importance of e-Waste disposal.
- identify the importance of green computing concept.
- classify the different types of software.
- list the functions of operating system.
- use word processor, electronic spreadsheets and presentation software.
- classify the different types of computer languages.
- list the use of different types of utility software.
- promote open source software.
- explain the term humanware or liveware.

Sample questions

Very short answer type

1. What are the components of a digital computer?
2. Write the main functions of central processing unit.
3. What are the different types of main memory?
4. What is the advantage of EEPROM over EPROM?
5. When do we use ROM?
6. What is an input device? List few commonly used input devices.
7. What do you mean by an output device? List few commonly used output devices.
8. What is a storage device? List few commonly used storage devices.
9. What is the role of ALU?
10. What is a control unit?

11. What are registers? Write and explain any two of them.
12. Differentiate Hard copy and Soft copy.
13. What is e-Waste?
14. What is operating system?
15. What is a language processor?
16. Mention the categories of computer languages.
17. What is disk defragmenter?
18. What is proprietary software?
19. What do you mean by open source software?

Short answer type

1. Briefly explain any three input devices.
2. Compare CRT with LED monitor.
3. Differentiate RAM and ROM.
4. List and explain e-Waste disposal methods.
5. Enumerate the steps that can be taken for the implementation of green computing philosophy.
6. What do you mean by customized software? Give examples.
7. Distinguish between low level and high level languages.
8. Differentiate compiler and interpreter.
9. Describe the use of electronic spreadsheets.
10. What is utility software? Give two examples.
11. Categorise the software given below into operating system, application packages and utility programs.

    Linux, Tally, WinZip, MS-Word, Windows, MS-Excel

12. Differentiate between freeware and shareware.
13. What are the four freedoms which make up free and open source software?
14. What do you mean by humanware? Give any two examples.

Long answer type

1. Describe in detail the various units of the Central Processing Unit.
2. Briefly explain various types of memory.
3. Explain the classification of printers.
4. "e-Waste is hazardous to our health and environment." Justify the statement. List and explain the methods commonly used for e-Waste disposal.
5. Define the term green computing. List and explain the approaches that you can adopt to promote green computing concepts at all possible levels.
6. List and explain various categories of software.
7. Describe the use of various utility softwares.
8. Define the term 'operating system'. List and explain the major functions of operating system.
9. List and explain general purpose application software with examples.