3

Key concepts

- **Data processing**
- **Functional units of a computer**
- **Hardware**
  - Processors
  - Motherboard
  - Memory - primary storage, secondary storage
  - Use of memory in computer
  - Input output devices
- **e-Waste**
  - Disposal methods
  - Green computing
- **Software**
  - System software (operating system, language processors, utility software)
  - Application software (general purpose, specific purpose)
  - Free software and open source software
  - Freeware and shareware
  - Proprietary software
- **Humanware / Liveware**

Components of the Computer System

We are familiar with computers and their uses in today's world. 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, we define the tasks required to process data for generating information. This chapter presents the concepts of data processing at first and discusses how the functional units of a computer help data processing. Then various hardware components are presented followed by electronic waste, its disposal methods and the concept of green-computing. A detailed classification of software is listed along with different types of computer languages. We will also discuss the concepts of open source, freeware, shareware and proprietary software.

3.1 Data processing

Data processing refers to the operations or activities performed on data to generate information. Data denotes raw facts and figures such as numbers, words, amount, quantity, etc. that can be processed or manipulated. Information is a meaningful and processed form of data. It adds to our knowledge and helps in making decisions. Data processing proceeds through six stages as in Figure 3.1.

(a) Capturing data
(b) Input of data
(c) Storage of data
(d) Processing / manipulating data
(e) Output of information
(f) Distribution of information

Let us take a close look at these stages.

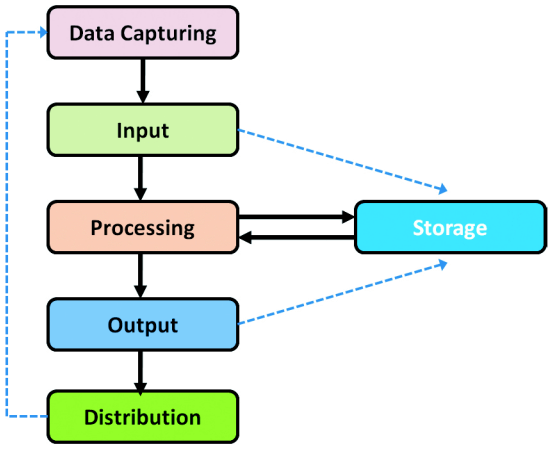


Fig. 3.1 : Data processing stages

Capturing Data: This is the first stage in data processing. Here a proforma, known as the source document, is designed to collect data in proper order and format. This document is used for data collection.

Input: In this stage, the data collected through the source documents is fed to the computer for processing. But now a days, in many cases, the data are directly fed into the computer without using source documents.

Storage: In data processing, the input data are stored before processing. The information obtained after processing may also be stored.

Process: The data stored in computers is retrieved for processing. Various operations like calculation, classification, comparison, sorting, filtering, summarising, etc. may be carried out as part of processing.

Output: The processed data is obtained in this stage in the form of information. The output may be stored for future reference as it may be used for generating some other information in another context.

Distribution of information: The information obtained from the output stage is distributed to the beneficiaries. They take decisions or solve problems according to the information.

We have seen the activities involved in data processing. Computers are designed in such a way that it can be involved in these activities. Let us see how the functional units of a computer are organised.

3.2 Functional units of a computer

Even though computers differ in size, shape, performance and cost over the years, the basic organisation of a computer is the same. As we discussed in Chapter 1, it is based on a model proposed by John Von Neumann, a mathematician and computer scientist. It consists of a few functional units namely, Input Unit, Central Processing Unit, Storage Unit and Output Unit as shown in Figure 3.2. Each of these units is assigned to perform a particular task. Let us discuss the functions of these units.

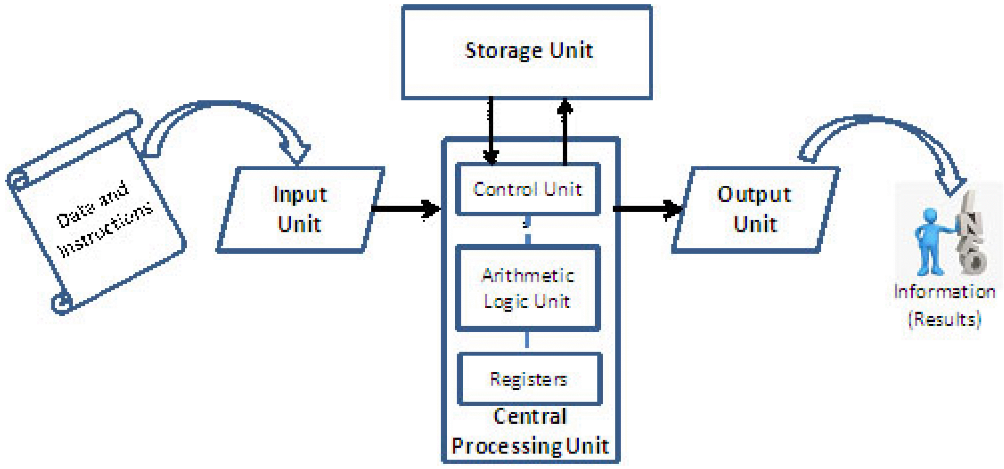


Fig. 3.2 : Basic organisation of computer

a. Input unit

The collected data and the instructions for their processing are entered the computer through the input unit. They are stored in the memory (storage unit). The data may be in different forms like number, text, image, audio, video, etc. A variety of devices are available to input the data depending on its nature. Keyboard, mouse, scanner, mic, digital camera, etc. are some commonly used input devices. In short, the functions performed by input unit are as follows:

1. Accepts instructions and data from the outside world.
2. Converts these instructions and data into a form acceptable to the computer.
3. Supplies the converted instructions and data to the computer for processing.

b. Central Processing Unit (CPU)

The CPU is the brain of the computer. In a human body, all major decisions are taken by the brain, and other parts of the body function as directed by the brain. Similarly, in a computer system, all major calculations and comparisons are made inside the CPU. It is also responsible for activating and controlling the operations of other units of the computer. The functions of CPU are performed by three components - Arithmetic Logic Unit (ALU), Control Unit (CU) and Registers.

i. Arithmetic Logic Unit (ALU)

The actual operations specified in the instructions are carried out in the Arithmetic Logic Unit (ALU). It performs calculations and logical operations such as comparisons and decision making. The data and instructions stored in the storage unit are transferred to the ALU and the processing takes place in it. Intermediate results produced by the ALU are temporarily transferred back to the storage and are retrieved later when needed for further processing. Thus there is a data flow between the storage and the ALU many times before the entire processing is completed.

ii. Control Unit (CU)

Each of the functional units has its own function, but none of these will perform the function until it is asked to. This task is assigned to the control unit. It invokes the other units to take charge of the operation they are associated with. It is the central nervous system that manages and coordinates all other units of the computer. It obtains instructions from the program stored in the memory, interprets the operation and issues signals to the unit concerned in the system to execute them.

iii. Registers

These are temporary storage elements that facilitate the functions of CPU. There are variety of registers; each is designated to store unique items like data, instruction, memory address, results, etc.

c. Storage unit

The data and instructions entered in the computer through input unit are stored inside the computer before actual processing starts. Similarly, the information or results produced after processing are also stored inside the computer, before transferring to the output unit. Moreover, the intermediate results, if any, must also be stored for further processing. The storage unit of a computer serves all these purposes. In short, the specific functions of storage unit are to hold or store:

1. Data and instructions required for processing.
2. Intermediate results for ongoing processing.
3. Final results of processing, before releasing to the output unit.

The storage unit comprises of two types of storages as detailed below:

i. **Primary storage:** It is also known as main memory. It is again divided into two – Random Access Memory (RAM) and Read Only Memory (ROM). RAM holds instructions, data and intermediate results of processing. It also holds the recently produced results of the job done by the computer. ROM contains instructions for the start up procedure of the computer. The Central Processing

Unit can directly access the main memory at a very high speed. But it has limited storage capacity.

ii. **Secondary storage:** It is also known as auxiliary storage and it takes care of the limitations of primary storage. It has huge storage capacity and the storage is permanent. Usually we store data, programs and information in the secondary storage, but we have to give instruction explicitly for this. Hard disk, CDs, DVDs, memory sticks, etc. are some examples.

d. Output unit

The information obtained after data processing is supplied to the outside world through the output unit in a human-readable form. Monitor and printer are the commonly used output devices. The functions performed by output unit can be concluded as follows:

1. Receives the results produced by the CPU in coded form.
2. Converts these coded results to human-readable form.
3. Supplies the results to the outside world.

3.3 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 electro mechanical components. These hardware components are associated with the functional units of a computer. Let us discuss some of these components.

3.3.1 Processors

In the previous section, we learned that CPU (Central Processing Unit) 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. 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. Figure 3.3 shows the processors developed by some manufacturers. 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. The commonly used processors are Intel core i3, core i5, core i7, AMD Quadcore, etc.

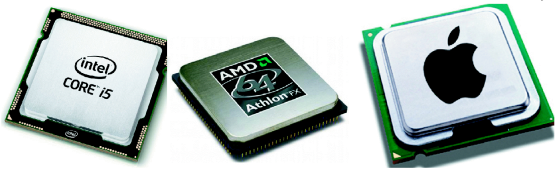


Fig. 3.3 : Different Processors

Registers are storage locations inside the CPU, whose contents can be accessed more quickly by the CPU than

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 the instructions the CPU can execute per second. Another factor is the architecture of the chip. The number of bits the 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.

other memory. Registers are temporary storage areas for instructions or data. They are not a part of memory; rather they are special additional storage locations that offer 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:

i. **Accumulator:** The accumulator is a part of the arithmetic/logic unit (ALU). This register is used to store intermediate result while performing arithmetic and logical operations. It is also called register A.

ii. **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.

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

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

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

3.3.2 Motherboard

A motherboard is a large Printed Circuit Board (PCB) to which all the major components including the processor are integrated. It also provides expansion slots for adding additional circuit boards like memory, graphics card, sound card, etc. (refer Figure 3.4). The motherboard must be compatible with the processor chosen.

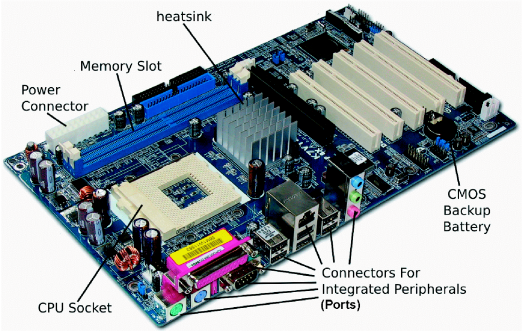


Fig. 3.4 : Motherboard

3.3.4 Peripherals and 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. Peripherals include input and output devices, external storage and communication devices. These devices communicate with the motherboard through the ports like VGA, PS/2, USB, Ethernet, HDMI, etc. that are available on the motherboard. Figure 3.5 shows some ports used in personal computers.

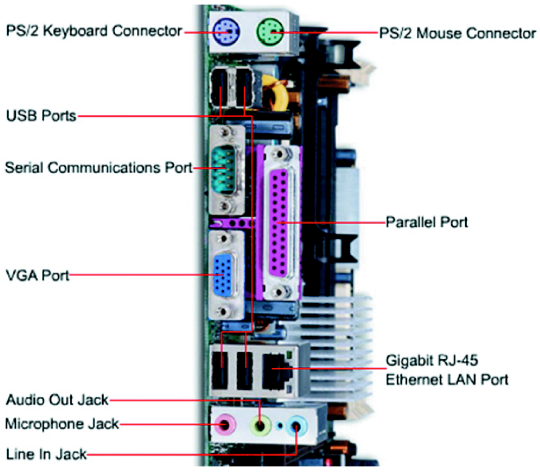


Fig. 3.5 : Ports

3.3.5 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. The measuring units are:

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, shown in Figure 3.6 refers to the main memory that microprocessor can read from and write into. 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. The contents of RAM are lost when power is switched off. Therefore, RAM is a volatile memory. Storage capacity of RAM is 2 GB and above.

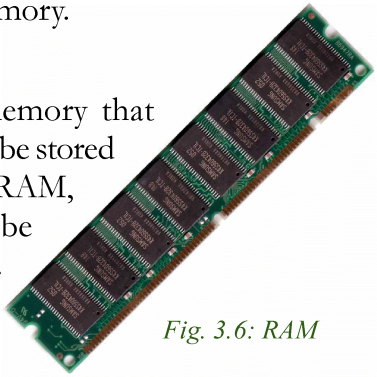


Fig. 3.6: RAM

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)

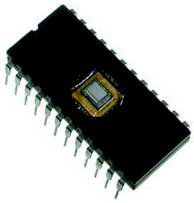


Fig.: 3.7 : ROM Chip

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, shown in Figure 3.7, 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. There are some modified types of ROM that include:

1. PROM - Programmable ROM which can be programmed only once.
2. EPROM - Erasable programmable ROM that can be rewritten using ultra violet radiation.
3. EEPROM - Electrically Erasable Programmable ROM which can be rewritten electrically.

Table 3.1 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 3.1 : RAM - ROM comparison

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 the RAM. Cache is more expensive than RAM, but it is worth getting a CPU and motherboard with built-in cache in order to maximise system performance.

b. Secondary or Auxiliary storage

Secondary memory is permanent in 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 can also act 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, hard disks, etc.

ii. Optical storage devices

Optical disk is a data storage medium which uses low-powered laser beam to read 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. The laser beam reads this pits and lands as 0s and 1s. Optical disks are very cheap to produce in large quantities and are popular secondary storage media. The main types of optical disks are CD, DVD and Blu-Ray.

iii. Semi-conductor 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 drawback is that they are limited to a certain number of write cycles. The different variants of flash memories are USB flash drives and flash memory cards. Figure 3.8 shows different types of flash memories.

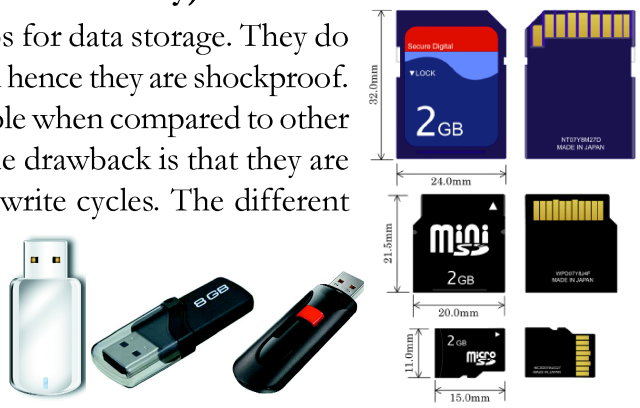
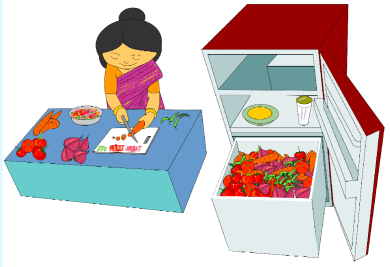


Fig. 3.8: Flash drive and memory cards

To see how registers, primary memory and secondary storage work together in a computer, let us use the analogy of making a salad in our kitchen. Suppose 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 chopped 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).

3.3.6 Role of memories in computers

Let us 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 - bonuses, deductions, etc. is taken to the cache. The data representing the hours worked and the rate of pay is moved to their respective registers. Using data on the hours worked and the rate of pay, 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.

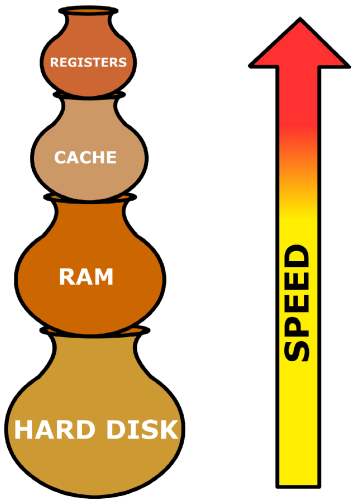


Fig. 3.9 : Memory hierarchy

Figure 3.9 depicts the hierarchy of different memories according to the storage capacity and access speed.

Table 3.2 summarises the characteristics of various kinds of data storage in the storage hierarchy.

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

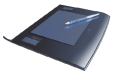
Table 3.2 : Comparison of different characteristics of various types of memories

Check yourself

1. The fastest memory in a computer is _____ .
2. Define data processing.
3. What is cache memory?
4. What is the use of program counter register?
5. What is the use of ALU?

3.3.7 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 presents information from a computer system. These input/output devices are connected to the CPU through various ports or with the help of wireless technology. Since they reside outside the CPU, they are called peripherals. The following table shows various **input devices** and their uses.

Device	Features / Uses
Keyboard 	Allows the user to input text data consisting of alphabets, numbers and other characters. Detects the key pressed and generates the corresponding ASCII code which can be recognised by the computer.Wired and wireless keyboards are available.
Mouse 	A small handheld device used to position the cursor or move the pointer on the computer screen by rolling it over a mouse pad / flat surface. Different types of mouse are ball, optical and laser mouse. Wireless mouse is also available.
Light pen 	A pointing device shaped like a pen. Has the advantage of 'drawing' directly onto the screen. Used by engineers, artists, fashion designers for Computer Aided Designing (CAD) and drawing purposes.
Touch screen 	Allows the user to operate/make selections by simply touching on the display screen. It can also be operated using a stylus which gives more precision.
Graphic tablet 	Consists of an electronic writing area and a special 'pen' that works with it.Allows artists to create graphical images with actions similar to traditional drawing tools.
Joystick 	Used to playing video games, control training simulators and robots. Has a vertical stick which can move in any direction and a button on top that is used to select the option pointed by the cursor.
Microphone 	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 later processing or playback.

Scanner 	Allows capturing of information, like pictures or text and converting it into a digital format that can be edited using a computer. Quality of the image depends on the resolution of the scanner. Different variants of scanners are flat bed, sheet feed and hand held scanner. Optical Character Recognition (OCR) software is used to recognise the text in an image scanned and convert it into text, which can be edited by a text editor.
Optical Mark Reader (OMR) 	Another scanning device that reads predefined positions and records where marks are made on the printed form. Useful for applications in which large numbers of hand-filled forms need to be processed quickly with great accuracy, such as objective type tests and questionnaires.
Barcode/Quick Response (QR) code reader  	A bar code is a set of vertical lines of different thicknesses and spacing that represent a number. Barcode readers are used to input data from such set of barcodes. Hand-held scanners, mobile phones with camera and special software are used as barcode readers. QR (Quick Response) code is similar to barcodes. Barcodes are single dimensional where as QR codes are two dimensional. 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 with a camera and special software installed.
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. Iron oxide has magnetic properties. MICR reader 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.
Biometric sensor 	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.

Smart card reader 	Smart card is a plastic card that stores and transacts data. It may contain a memory or a micro processor. Used in banking, healthcare, telephone calling, electronic cash payments and other applications. These are used to access data in a smart card.
Digital camera 	Takes pictures and videos and converts it to the digital format. The images are stored in the memory and can be transferred to computer. 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.

Table 3.3 : Input devices and their uses

Now let us see some **output devices** and their features. Table 3.4 shows various output devices and their uses.

Device	Features / Uses
Visual Display Unit (VDU) 	Display devices include CRT monitors, LCD monitors, TFT monitors, LED monitors, gas plasma monitors, Organic Light Emitting Diode (OLED) Monitors, etc. Information shown on a display device is called soft copy. The size of a monitor is measured diagonally across the screen, in inches.
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. A beam of high-intensity light which travels through thousands of shifting pixels in an LCD is focused by a lens on the surface.
Printer  	Used to produce hardcopy output. The output printed on paper is known as hardcopy. Classified as Impact or Non-impact printers. Dot-matrix uses impact mechanism. It can print carbon copies with less printing cost. Speed is measured in 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). These printers are slow and noisy. Inkjet printers are non-impact printers that form the image on the page by spraying tiny droplets of ink from the print head. Ink jet printers are inexpensive, but the cost of ink cartridges makes them costly to operate in the long run. Laser printers are non-impact printers that

 	produce good quality images. Monochrome and color laser printers are available. Color laser printers use multiple color toner cartridges to produce color output and are expensive. Laser printers are faster and their speed is rated in pages per minute (ppm). Thermal printer is a non-impact printer that 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. It is popular as a portable printer.
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. Plotters are of two types: Drum plotters and Flatbed plotters. A drum plotter is also known as Roller plotter. A flatbed plotter is also known as Table plotter.
3D printer 	A 3D printer is an output device used to print 3D objects. It can produce different kinds of objects, in different materials, using the same printer. The 3D printing process turns the object to be printed, into thousands of tiny little slices. It then prints it from the bottom to top, slice by slice. Those tiny layers stick together to form a solid object.
Audio output device 	The audio output is the ability of the computer to produce sound. Speakers are the output devices that produces sound. It is connected to the computer through audio ports.

Table 3.4 : Output devices and their uses

We have seen different types of printers. Table 3.5 shows a comparison on various characteristics of these printers.

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 and 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, prints are not fast, makes noise.

Table 3.5 : Comparison of printers

3.4 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.

3.4.1 Why should we be concerned about e-Waste?

Electronic waste is not just waste. It contains some very 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 up to 40% of the lead found in landfills. Important hazardous chemicals, their sources and consequences are listed in Table 3.6.

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 the kidney and harm it.
BFRs-Brominated Flame Retardants	Found in printed circuit boards and some plastics.	These toxins may increase the risk of cancer.

Table 3.6 : Hazardous chemicals, its source and consequence

3.4.2 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) includes 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. 3.10 : Defective and obsolete electronic items

e-Wastes 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-Wastes.

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.

3.4.3 e-Waste disposal methods

The following 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 widely used but not recommended method for the disposal of e-Waste.

Role of students 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.

3.4.4 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 3.11.

Fig. 3.11 : Energy Star label

Government regulation is only a part of an overall green computing idea. The work habits of computer users and business firms 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. The labelling programme to promote energy efficiency in computers and their resources is called _____.
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.*

3.5 Software

Software is a general term used to denote a set of programs that help us to use the 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 or soul. There are two types of software:

- System software
- Application software

3.5.1 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 users to use computer in an effective manner. It implies that system software helps to manage resources of the computer. Figure 3.12 depicts how system software interfaces between user and hardware.

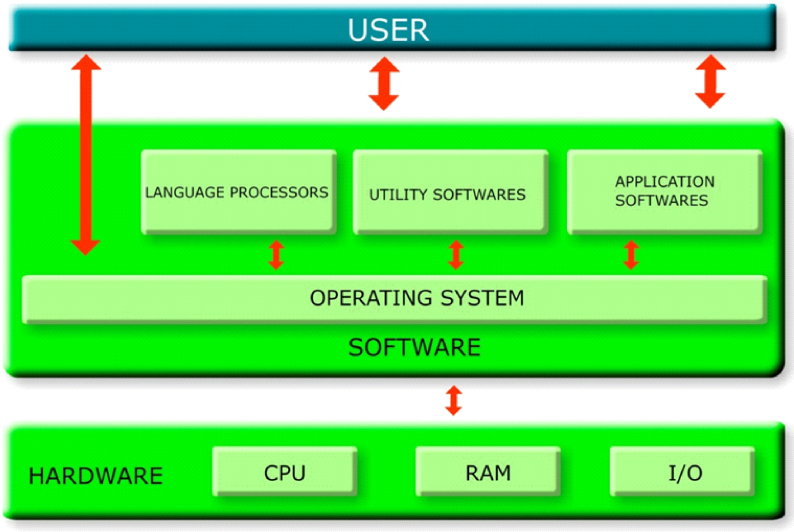


Fig.3.12: Software with user and hardware interface

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 as shown in Figure 3.13. 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.

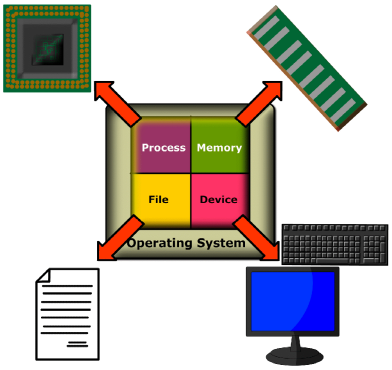


Fig. 3.13 : Operating System as a resource manager

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

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 deallocation 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 whether it is allocated to some process or it is 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. An 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 3.14 shows process involved in the translation of assembly language and high level language programs into machine language programs

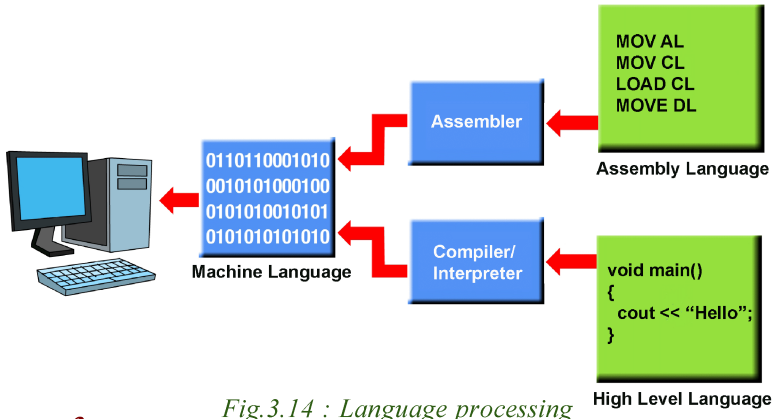


Fig.3.14 : Language processing

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.

- **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.

3.5.2 Application software

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

a. General purpose software packages

General purpose software are used to perform tasks 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, Apple iWork Pages, 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 iWork 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, Apple iWork Keynote 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, Postgres SQL, 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 custom 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 3.7.

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 3.7 : Examples of application software

Let us do

- *Discuss the classification of software.*
- *Compare and contrast the features of Linux and Windows operating systems with the help of your teacher and prepare short notes (Lab Demonstration). Discuss the role of utility software.*
- *Write short notes on the following:*
  - *Language processors*
  - *General purpose software packages*

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. Name the two different language processors which translate high level language programs into machine language programs.
7. Differentiate between compiler and interpreter.
8. DBMS stands for _____.
9. Give two examples for customized software.
10. Duplicating disk information is called _____.

3.5.3 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.

3.5.4 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 users a chance to analyse the software before purchasing it. Some shareware works for a limited period of time only. Table 3.8 highlights a comparison between freeware and shareware:

Freeware	Shareware
• Freeware refers to software that anyone can download from the Internet and use for free.	• Shareware gives 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 3.8 : Comparison of Freeware and Shareware

3.5.5 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 cannot be changed for improved by the user. Some examples of proprietary software are Microsoft Windows operating system, MS Office, Mac OS, etc.

3.6 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. Table 3.9 shows various categories of humanware and their job description.

Humanware	Job Description
System Administrators	Upkeep, configuration and reliable operation of computer systems; especially multi-user computers such as servers.
System 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 3.9 : Categories of humanware with job description

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. Give an example for proprietary software.
5. Give two examples of humanware.

Let us sum up

Data processing is a series of activities by which data is converted into information. The limitations of manual data processing are overcome by electronic data processing and computer is the best electronic data processing machine. A computer has five functional units such as input unit, storage unit, arithmetic and logic unit, control unit and output unit. This chapter provided a general overall introduction to computer organisation. Input and output devices, e-waste and its disposal methods and the importance of green computing were introduced. The classification of software and the need of operating system in a computer with its major functions were discussed. Following this, the categories of computer languages were presented. The concepts of open source, freeware, shareware, free software and proprietary software were also discussed in detail. The chapter concluded outlining the concept of humanware.

Learning outcomes

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

- distinguish between data and information.
- identify various stages in data processing.
- explain basic organisation of computer system.
- recognise the 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.
- recognise the functions of operating system.
- use word processor, electronic spreadsheets and presentation software.
- classify the different types of computer languages.
- list the different types of utility software.
- promote open source software.
- explain the term humanware or liveware.

Sample questions

Very short answer type

1. What is data?
2. Processed data is known as _____.
3. What are the components of a digital computer?
4. Write the main functions of central processing unit.
5. What are the different types of main memory?
6. What is the advantage of EEPROM over EPROM?
7. When do we use ROM?
8. What is an input device? List few commonly used input devices.
9. What do you mean by an output device? List few commonly used output devices.
10. What is a storage device? List few commonly used storage devices.
11. What is the role of ALU?
12. What is a control unit?
13. What are registers? Write and explain any two of them.
14. Differentiate hard copy and soft copy.
15. What is e-Waste?
16. What is operating system?
17. What is a language processor?
18. Mention the categories of computer languages.
19. What is disk defragmenter?
20. Why is OS considered as a 'resource manager'?
21. What is proprietary software?
24. What do you mean by open source software?

Short answer type

1. Distinguish between data and information.
2. The application form for Plus One admission contains your personal details and your choice of groups and schools.
   (a) Identify the data and information in the admission process.
   (b) Explain how the information helps the applicants and school authorities.
   (c) Write down the activities involved in the processing of the data.

3. Briefly explain any three input devices.
4. Compare CRT with LED monitor
5. Differentiate between RAM and ROM
6. List and explain e-waste disposal methods.
7. Enumerate the steps that can be taken for the implementation of green computing philosophy.
8. What do you mean by customised software? Give examples.
9. Distinguish between low level and high level languages.
10. Differentiate compiler and interpreter.
11. Describe the use of electronic spreadsheets.
12. What is utility software? Give two examples.
13. Categorise the software given below into operating system, application packages and utility programs. Linux, Tally, WinZip, MS-Word, Windows, MS-Excel
14. Differentiate between freeware and shareware.
15. What are the four freedoms which make up free and open source software?
16. What do you mean by human-ware? Give any two examples.

Long answer type

1. Taking the case of a real life example, briefly describe the activities involved in each stage of data processing.
2. With the help of a block diagram, explain the functional units of a computer.
3. Describe in detail the various units of the Central Processing Unit.
4. Briefly explain various types of memory.
5. Explain classification of printers.
6. "e-Waste is hazardous to our health and environment." Justify the statement. List and explain the methods commonly used for e-Waste disposal.
7. Define the term green computing. List and explain the approaches that you can adopt to promote green computing concepts at all possible levels.
8. List and explain various categories of software.
9. Describe the use of various utility software.
10. Define the term 'operating system'. List and explain the major functions of operating system.
11. List and explain general purpose application software with examples.
12. Compare freeware and shareware.