Module 1: Concepts of Information Technology (IT)

Section 2: Hardware

1.2.1 Central Processing Unit

1.2.1.1 Understand some of the functions of the CPU in terms of calculations, logic control, immediate access memory. Know that the speed of the CPU is measured in megahertz (MHz) or gigahertz (GHz).

Parts of the CPU

There are three main components to the CPU: the arithmetic-logic unit (ALU), control unit and on-board cache memory.

Control unit: The control unit is responsible for loading and interpreting the individual instructions that comprise the computer program. These instructions are in a language called **machine code**. Machine code is a pattern of ones and zeros. The control unit also has the task of getting the data needed by the instructions and returning the results of the processing after the instruction has been executed.

Arithmetic-logic unit: The ALU is responsible for carrying out arithmetic operations such as addition and subtraction as well as logical decisions such as whether one number is bigger than another. All programs consist of complex sets of arithmetic and logical operations. Another way of thinking of a logical operation is as a decision making operation.

On-board cache memory: Because the CPU can perform its operations much faster than data can be transferred from RAM, many CPUs have on-board cache memory. This is memory that the control unit can access very quickly and use for intermediate storage. Further, data and instructions can be loaded into cache before they are actually needed. When they are needed, the transfer is much faster than it would have been if RAM had been used.

Speed of the CPU: The CPU operates as a result of electronic pulses sent to it by another device on the motherboard called the clock. The speed of a CPU is measured by the maximum number of pulses it is able to handle. This is measured in MHz (megahertz) or millions of pulses per second or GHz (gigahertz) thousands of millions of pulses per second. A good personal computer will use a CPU with a clock speed of over 2 GHz. This means it receives 2 000 000 000 million pulses every second from the CPU.

Previously CPUs could only do one operation per pulse. With improvements in technology, they have been able to improve on this. For example, they can do one operation at the start of the pulse and one at the end of the pulse.

1.2.2 Memory

1.2.2.1 Understand different types of computer memory such as: RAM (random-access memory), ROM (read-only memory) and distinguish between them.

As mentioned in the first chapter RAM is used to store the current data and programs whereas ROM is used to store the routines that enable a computer to boot up.

The following table compares RAM and ROM.

	RAM	ROM
Function	Store the currently active programs and their data.	Stores certain fixed routines such as the boot-up routines.
Volatility	RAM is volatile: When the computer is switched off, the contents are lost.	ROM is non-volatile: When the computer is switched off, the contents are not lost.
Changeable	The contents of RAM can be changed or deleted.	The contents of ROM cannot be changed or deleted.

1.2.2.2 Know how computer memory is measured: bit, byte, KB, MB, GB, TB. Relate computer memory measurements to characters, files and directories/folders.

Bits

In all the components of a computer, data and instructions are stored as patters of ones and zeros. These individual ones and zeros are called bits.

In electronic components the one is stored by switching an electronic switch on and a zero by switching it off. On a magnetic material, such as the surface of a hard disk, the one may be stored with a clockwise magnetic field and a zero with a counter-clockwise field.

The reason for the use of only ones and zeros stems directly from the fact that modern circuitry makes use of electronic switches and these can only be on or off. The term for circuitry based on switches is **digital**. Arithmetic based on the use of only ones and zeros is called **binary arithmetic**.

Bytes

Bits are grouped together into sets of eight. A set of eight bits is called a **byte**.

ASCII or **American Standard Code for Information Interchange** was a system of representing all the characters of the western alphabet and certain special characters in a single byte. You can think of the byte as the amount of memory required to store a single character.

As there are only 256 possible variations within eight bits, this is not sufficient to represent other alphabets. As a result a new system, called **uni-code**, has been developed to represent all the alphabets of the world. This makes use of two bytes or sixteen bits. With two bytes, 65536 different characters and symbols can be represented.

Units of memory

Because we use very large numbers of bytes for storage, abbreviations are used for large numbers. These are based on powers of two and are set out in the following table.

kB	kilobyte	2^{10} = 1 024 bytes	approx. 1 000 bytes
Mb	Megabyte	2^{20} = 1 048 576 bytes	approx. 1 000 000 bytes
Gb	Gigabyte	2^{30} bytes	approx. 1000 000 000 bytes
Tb	Terabyte	2^{40} bytes	approx. 1000 000 000 000 bytes

The capacity of hard drives is measured in bytes. A modern hard drive has a capacity of 40 Gb or more.

When files are stored on disk, the amount of space they occupy is measured in bytes. The following screen shows a partial listing of files in a directory. Notice the fourth column which contains the size of the file in bytes. (Don't be concerned with the detail of this screen – it is shown purely for illustrative purposes.)

```
[david@Linux1 david]$ ls -l
total 636
drwxrwxr-x    3 david    david        4096 Jan 20 18:32 Desktop/
drwxr-xr-x    2 david    david        4096 Jan 11 15:34 Documents/
-rw-r--r--    1 root     root        42853 Jan  6 12:49 MyFirstDocument.sxw
-rw-rw-r--    1 david    david       60088 Jan 11 13:42 snapshot10.png
-rw-rw-r--    1 david    david       13241 Jan 11 15:36 snapshot11.png
-rw-rw-r--    1 david    david       56729 Jan 21 17:35 snapshot1.png
-rw-rw-r--    1 david    david       25389 Jan 20 16:30 snapshot2.png
-rw-rw-r--    1 david    david      104870 Jan 20 15:19 snapshot3.png
-rw-rw-r--    1 david    david       89470 Jan 20 15:20 snapshot4.png
-rw-rw-r--    1 david    david       29193 Jan 20 15:21 snapshot5.png
```

When we work with files and directories, we often need to know how large the files are or how much space a directory and its files occupies.

- One **byte** is one character which is a number, letter or symbol. It consists of eight bits (binary digits) and is the smallest unit of information a computer can process.
- One **kilobyte** is 1,024 characters and is approximately equal to one page of text in double-spacing.
- One **megabyte** is 1,048,576 characters and is approximately equal to one book.
- One **gigabyte** is 1,073,741,824 characters and is approximately equal to 1000 books.
- One **terabyte** is 1,099,511,627,776 characters and is approximately equal to a whole library.

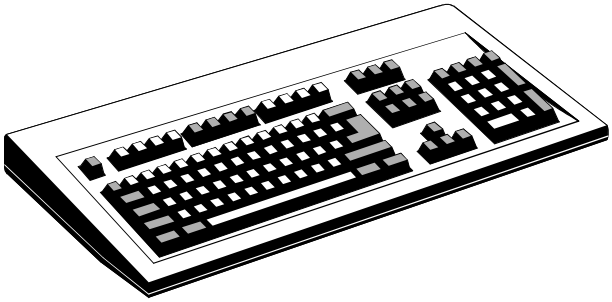
1.2.3 Input Devices

1.2.3.1 Identify some of the main devices for inputting data into a computer such as: mouse, keyboard, trackball, scanner, touchpad, lightpen, joystick, digital camera, microphone.

Any device which allows us to send data or instructions to the computer can be regarded as an input device. We can use any mechanical movement, sound, light, heat or electronic signals to input data and instructions.

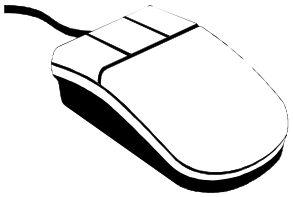
Keyboard

The most familiar input device is the keyboard. Users type the text directly into the computer.



There are a number of layouts of the keyboard. The most important are the language variations. For example, the US and UK keyboards are quite similar but are very different from the French keyboard.

Mouse

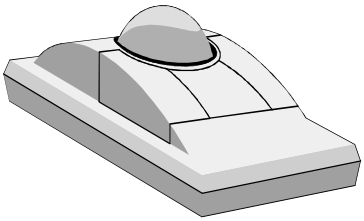


The mouse is a point and click device. As you move the mouse across a surface, it senses this movement either mechanically or optically. This is translated into the movement of a pointer on the screen. Functions are represented as icons on the screen. When you click on these using a mouse button, the function is executed.

Touchpad

A touchpad is a device that senses pressure to guide the pointer on the computer screen. It is generally a small square area below the keyboard. As the user moves his/her finger across the touchpad, the pointer moves on the screen. Next to the pad are two buttons used for clicking in exactly the same way as those on a mouse.

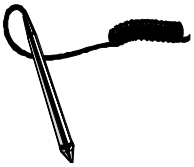
Trackball



A trackball acts as a type of overturned mouse. The ball is on the top side of the object. By rolling the ball you can move the pointer across the screen. Some keyboards have an in-built trackball.

The trackball has been superseded by the touchpad.

Lightpen

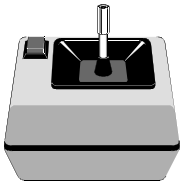


A light pen is a device which is sensitive to variations in patterns on a surface. Light pens act like a miniature scanner and can read text as they are dragged across the printed page. This can be transferred directly to the current open document.

Bar code reader

A bar code is a pattern of vertical lines in which the spacing and thickness can be used to represent data. A bar code reader is a device that can read and interpret bar codes and input the data into the computer.

Joystick



A joystick is a device that is familiar for use in games to move objects on the screen. However, it is also used to control the movements in computerised industrial machines such as lathes. It consists of a small vertical lever which can move in any direction. These movements are translated to the computer which in turn uses them to control the movements of machinery.

Digital camera

Instead of film, a digital camera uses a light sensitive screen at the back of the camera. A small computer inside the camera converts the pattern on the screen into a standard graphics file which can then be transferred to a computer.

Microphone

A microphone translates speech into an electronic signal. Modern speech recognition software is able to translate this into either commands or data. This enables the user to use a microphone as an alternative to the keyboard.

Scanner

A scanner is similar to a photocopier, except that instead of producing a paper copy of the document you place on it, you get an electronic copy which appears on your computer screen.

Text recognition software can be used with a scanner. This software is able to recognise the individual letters in the image. Instead of creating a single image of the document, the software inserts actual text into your application which can then be edited.

1.2.4 Output Devices

1.2.4.1 Identify common output devices for displaying the results of processing carried out by a computer, such as: monitors, screens, printers, plotters, speakers. Know where these devices are used.

An output is any device that the computer uses to send the results of processing to the user. The output can be a hard copy (paper), visual or sound.

Visual Display Unit (VDU)

Virtually all computers use some type of screen as their primary output device. There are two categories of screen: cathode ray tube and LCD.

CRT screens: The cathode ray tube (CRT) type screen is usually called a **monitor** and makes use of the same technology as a television screen. A beam of electronics is fired from an electronic gun at the back of the tube. This strikes the front of the tube which is covered in a phosphorescent material which glows when struck by electrons. Between the electron gun and the screen the beam is modulated by a signal to produce the image you see on the screen.

With CRT type screens, an important measure is the refresh rate. Roughly speaking, this is the number of times the image is refreshed every second. A low refresh rate makes the image appear to flicker. You need a refresh rate of at least 72 Hz (72 times a second) to avoid the appearance of flicker.

Solid state screens: Solid state screens, also known as LCD or Liquid Crystal Displays, make use of tiny transistors to emit light and create an image. Originally, LCD screens were confined to laptops, but they are increasingly used with desktops. They are usually called flat screens when used as separate units with desktops.

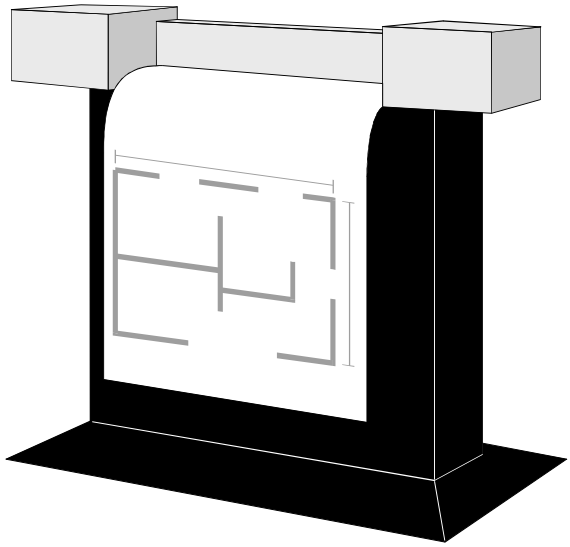
Resolution: An important characteristic of all screens is their resolution. Each point of light on the screen is called a **pixel**. The resolution of a screen is the maximum number of pixels that the screen can display. This is given as the number of pixels across (horizontal resolution) by the number of pixels down (vertical resolution). For example, 800 x 600. The greater the resolution the better. Modern screens can display 1024 X 768 or better.

Printers

Printers produce a hard copy of the output on paper. There are three main types of printer: Dot matrix, Inkjet and Laser. The following table compares the three types.

	Dot matrix	Inkjet	Laser
Initial cost	Low	Medium	High
Cost per printed page	Low	High	Medium
Speed	Low	Medium	High
High volumes	No	No	Yes
Noise level	High	Low	Low
Print quality	Low	Medium	High
Print graphics	No	Yes	Yes
Print in colour	No	Some	Some
Print source	Ink ribbon	Ink	Toner powder

Plotters



A plotter consists of a device that can move paper both backwards and forwards. On the top of the device one or more pens are able to move horizontally across the paper. The combined movement of the pens horizontally across the paper and the vertical movement of the paper allows complex continuous diagrams to be drawn.

Some plotters allow different colour pens to be used to create diagrams in multiple colours.

In other types of plotters, the paper lies on a flat bed. The mechanics of the plotter are so designed that the pens can move both across and down the paper to create the diagram.

Plotters are usually used in conjunction with CAD (Computer Assisted Design) programs. These are used in everything from the design of ships and machines to buildings.

Speakers

Modern computers using the appropriate software can turn text in a document into audible speech. This is known as **speech synthesis**. Other types of software allow music and other sounds to be created and played back.

The line between the computer and a home entertainment system is becoming blurred. Computers are able to play music directly from a CD or play a film from a DVD. You can even fit your computer with a radio or TV card to add these functions.

In all cases, the sound is transmitted through a speaker in the same way it is in a sound system or radio.

1.2.5 Input/Output Devices

1.2.5.1 Understand some devices are both input/output devices such as: touchscreens.

Some devices function as both input and output devices.

A touchscreen is a special type of screen in which the screen not only displays output but also responds to being touched.

A typical example is their use in autotellers at banks. Part of the screen contains information. Other parts may contain a menu. When you touch one of the icons on the screen, the system responds to the associated command.

Another example is to be found in information screens in shopping malls. The lower half of the screen consists of a number of icons representing menu items. If you touch one of these, either information will be displayed in the top half or a sub-menu will appear allowing you to refine your search for information.

PDAs have touch sensitive screens. You would use a special stylus to touch icons on the screen or to write. Character recognition software then converts your writing to input text for the PDA.

1.2.6 Storage Devices

1.2.6.1 Compare the main types of memory storage devices in terms of speed, cost and capacity such as: diskette, Zip disk, data cartridges, CD-ROM, internal, external hard disk.

Diskette

A diskette comprises a plastic flexible disk enclosed inside a tough plastic cover. At one end is a window. When the diskette is placed inside a diskette drive, the window is pushed to the side. The read-record head inside the drive makes contact with the magnetic disk.

Diskettes are slow and have a low capacity (1,44 Mb). Since they are cheap, they still tend to be commonly used for storing small amounts of data. Another advantage is that they can be used over and over again. Unfortunately, many are not very good quality and data can become corrupted and unusable. Because of this they are not suited to backup purposes. The disks can become corrupt through many causes including disk, heat, magnetism or moisture.

Zip disk

A zip disk is a removable magnetic disk which fits into a special zip drive. The surface is coated with a special scratch resistant material which makes a zip disk a very robust storage device. It comes in a number of capacities: 100, 250 and 750 Mb. The speed of a zip drive is faster than all but the very fastest of CD drives. Its robustness and speed make it an excellent backup device. However, its capacity is much less than that of hard drives and tape drives which limits its use for very large amounts of data.

Data cartridge

A data cartridge is a tape very similar to that found in a tape recorder, only much higher quality. These are used in a device called a **tape streamer** to record data. Data cartridges, especially if good quality, are reliable and cheap devices for creating backups of large quantities of data. They

are, however, rather slow. Data cartridges are **sequential devices** which means that to access an item of data on them, all the preceding data reads to be read first. They are tending to become obsolete as newer faster and more reliable technologies are available. A single tape can stored many Gb of data.

CD ROM

A CD ROM uses optical technology. When data is written, small pits are burned into the surface using a highly focussed laser beam. These are read by another laser beam.

There are two types of CD ROM used for storage. The CD-W disks can only be written to once. Once data has been written to part of the surface, this part can no longer be used. CD-RW disks are designed so that one set of data can overwrite another. This allows the disks to be re-used many times.

CD ROM provides a reliable and storage medium for backing up and storing data. The speed is greater than that of a diskette but slower than that of a hard drive. Writing to a CD ROM is a much slower process than reading it. The capacity of a CD ROM is 640 Mb. It is sometimes possible to store about 700 Mb on a disk.

CD ROM technology is improving all the time with continued improvements in quality and speed.

DVD

The **Digital Versatile Disk** is a development of the storage technology of the CD ROM. Using newer storage methods and higher quality media, a DVD can store about 4 Gb of data. This is enough to store a full length film.

Hard disk drive

A hard disk drive can be **internal** or **external**. An internal drive is housed inside the main unit and is connected directly to the motherboard of the computer. An external drive is housed inside a special caddy which connects to the computer through one of its ports. Most now use the USB or firewire ports to achieve maximum performance.

An external hard drive is a good backup medium and allows large quantities of data to be stored. Since the same drive can be connected at different times to different computers, these drives provide a useful way of transferring data between computers that are not connected through a network. As they are electromechanical devices, they are subject to mechanical failure if not handled with care. The small 2½" drives used in laptops make excellent external hard drives since they are constructed to be moved around.

Modern hard drives have capacities from 40 Mb to 120 Mb. They are also relatively cheap in terms of the storage capacity they offer.

Because they contain moving parts, they do eventually fail. When a hard drive fails is quite unpredictable. Any suspicious noise coming from a hard drive should be viewed with great caution and the data it contains should backed up immediately. The expected life span of a hard drive is measured as the **mean time between failures**. This is a very rough average of the working life. Figures of 250 000 hours are often quoted but these should be viewed with caution.

Numerous systems have been developed to protect data on hard disks. One of these is **mirroring** where the data is stored simultaneous on two disks. The one disk becomes the mirror image of the other. If one fails, the data is still one the other. In this case, the first disk is replaced, the system creates a mirror image of the first disk automatically and the system continues.

There are a number of measures of performance of a hard disk. One is the speed at which the

platters turn. Typically this is somewhere between 4800 and 7200 rpm. There are faster, more expensive disks. Another is the access time. This is the time it takes the disk to access an item of data. A good figure here would be around 10 ms. An ms or millisecond is one thousandth of a second. Disks are also sometimes compared in terms of their data transfer rates. This is a measure of how many bytes can be read or written per second.

Flash memory and memory sticks

A new type of external memory is the flash disk or memory stick. This is a solid state device (no moving parts) that connects to the computer via the USB port. It provides a very fast and reliable method of storing data externally.

They are at the moment fairly expensive, especially the larger capacity devices. They tend to be limited to a maximum of about 2 Gb. This figure can be expected to increase quite dramatically over time.

Relative cost of storage

As in the case of computers, the cost of memory is continually changing. The price varies from country to country as well as according to international demand. In order to compare the cost of memory, a common measure is to calculate the cost per Mb. The following table compares the cost per Mb of the different media.

Medium	Hard disk	CD	Data cartridge	Zip disk	Flash disk	Floppy disk
Relative cost per Mb	0.04	0.15	0.3	0.3	3	4

This table tells you that it is about 100 times as expensive to store a Mb of data on a floppy disk as it is on a hard drive.

Use this table with caution. Treat the values as very approximate relative values. In other words use them as comparative values, not as monetary values.

1.2.6.2 Understand the purpose of formatting a disk.

A new diskette or hard disk is not able to record data immediately. The disk first needs to be prepared by a process known as formatting. This marks out concentric circles called tracks. Each track is divided into a number of sectors. The tracks and sectors are marked out using magnetic markers.

As data is recorded on a disk, it fills up. To be able to re-use a disk, it may also be formatted. This releases the areas that contain data so that new data may be stored in its place. When a disk is reformatted, the old data is lost.

When data is stored on a disk, it is not always stored in a continuous pattern. Rather, the system stores data in the first free area it finds. When this has been filled, it looks for additional free space and continues storing the data. A file ends up being stored as a series of segments across the disk. This breaking up a a file into many segments is called fragmentation.

Fragmentation slows down the operation of the disk as the system needs to keep track of all the different segments. A disk may be re-organised to reduce fragmentation by a process called **defragmentation**.

There are different **file systems** available, but in all cases the disk needs to be prepared with the index area, tracks and sectors through formatting.

As mentioned previously, disk can be **reformatted**. In this process everything on the disk is erased and the disk is formatted as if it was a new disk.
The following diagram represents the tracks (green) and sectors (red triangular area) that are created when the disk is formatted and ready to store data.