COMPUTER STUDIES

MODULE

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WHAT IS A COMPUTER?

It is an electronic device that works under the control of stored programs to automatically accept, store and process data into information. Therefore, a computer has the following characteristics:

- **It is electronic**:- can only work when there is electricity
- **It is a device:** a machine
- **Is controlled by programs:** Works according to instructions, written in computer language, given by the user for it to perform a specific tasks.
- **Is automatic in operation**: Can work with minimum or no human intervention.
- **Can accept data**: data can be entered into the computer through various means and the computer accepts it.
- **Can store data and programs**: Data and programs entered into the computer can be stored for future use.
- Can process data into information

Data and Information

1. Data: refers to raw facts and figures of an activity. It can just be a list of numbers, names or a combination of these. Data is meaningless and needs to be processed. Data cannot be used for decision making purposes as it is meaningless.

2. Information: It is data that has been converted into meaningful form. In general it is processed data. Information can be understood and therefore can be used for decision making purposes. Information is meaningful. To get relevant information, data entered into the computer must be **relevant, accurate and up-to-date**. If data entered into the computer is wrong (Garbage In) the results will also be wrong (Garbage Out), and is generally referred to as **Garbage-In Garbage-Out (GIGO)**. It is a rule stating that the quality of the output is a function of the quality of the input; put garbage in and you get garbage out. Therefore the accuracy of the results produced by the computer depends on how accurate the user enters data, functions, formulae and codes program procedures.

The Data Processing Cycle
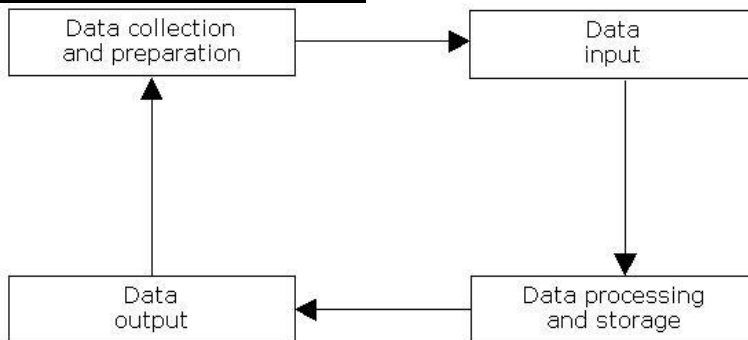
Computer Generations

Refers to stages through which computers developed from the 1940s to date. These are as follows:

1. **First Generation Computers (1945 -1955):** These are the earliest computers that used valves in controlling machines, e.g. EDVAC, ACE and UNIVAC machines. These were very large computers, fitting about the size of an average room. ~~They~~ were programmed in a language understandable by the machine. Such computers used a lot of electricity and were ~~very~~ expensive to purchase. Only very large organisation could afford these computers. Such computers were *huge*, *slow*, *expensive* and *often undependable*.

2. Second Generation Computers (1955 -1965): These are computers that used transistors instead of valves. They were faster, had reduced size, were more reliable and less expensive.
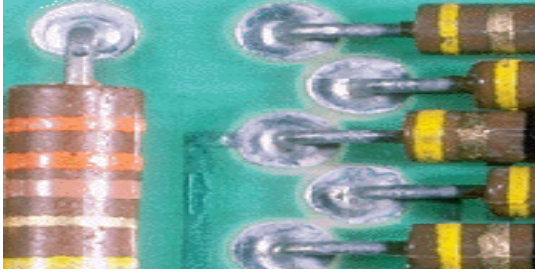
Transistor

Second generation computers were: faster, more reliable, smaller, much cheaper to build, gave off virtually no heat, conduct electricity faster

3. Third Generation Computers (1965 – 1980): These used integrated circuits e.g. the IBM (International Business Machines) computers. The integrated circuit, also referred to as semiconductor chip, packs a huge number of transistors onto a single wafer of silicon. These computers have *increased the power*, *lowered cost*, *carry out instructions in billionths of a second*, and *smaller*.

4. Fourth Generation Computers (1980-1990): The Fourth Generation Computers that used microprocessors and concentrated on miniaturisation of high processing components. Fourth Generation Computers are grouped into mainframe, mini, micro and super computers, depending on their sizes, capabilities and memory size.
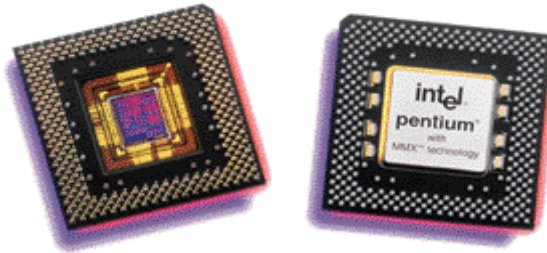
Microprocessor

5. Fifth Generation Computers (1990 to date and beyond): These use natural language and can flexibly interact with the human being. Such systems are used in medical diagnosis, mineral prospecting and in geological researches. Such computer systems are capable of human intelligence and are commonly called expert systems.

TYPES OF COMPUTERS

The types of computers are: **Micro-computers, mainframe computer, super computer & mini-computer.** They can also be **digital** or **analogue** computers**.**

1. **Micro Computers:** These are computers with a microprocessor inside them and occupy a small physical space. They are cheap, small, relatively slow and have limited memory, often single user, easy to use and have low computing power.
   Microcomputers include the following:

a. **Desktop Computers:** These are computers with a separate CPU and monitor and fit on a desk during usage. They are relatively cheap. They are easy to add expansion cards on them. However, they take up large desk space. They are not portable

b. **Personal Computers (PC):** - These are microcomputers made for use at home for general purpose, and includes desktop computers. They are cheap, more powerful and has good storage capacity disks.

   Advantages of desktop/PCs
   - Low cost
   - Spare parts tend to be standardised
   - Faster processors, 2.0 GHz
   - Large casing allows good dissipation of any heat build-up

   Disadvantages
   - Not portable
   - Take large desk space
   - All devices need to be wired together which might be too complex

c. **Palmtops:** These are portable microcomputers that can fit in the palm and pocket and are used as diaries and for other small business applications.

They are Handheld Computers that are small enough to be carried in a pocket and include **Personal Digital Assistants (PDAs)** and **Cell phones**. These are mostly used as diaries, word processing, faxing, internet browsing, calculator, contacts, etc. PDAs and all palmtops are portable. However, they are expensive and have limited expansion. They are even slow to input data using them.

d. **Laptops (Notebook computers):** - These are portable computers that use an internal battery for power and can be placed on laps during usage. The keyboard, pointing device, monitor and processor are all designed as one unit. They have LCD (Liquid Crystal Display) screens which are not as bright as most Monitors.

Laptop computer

Laptops are small like a briefcase and are portable and can be used in areas where there is no electricity. They have light weight and are battery powered. They consume less electricity. The processor does produce too much heat. They also do not have trailing wires as everything is in one unit. They can take full advantage of WIFI.

However, laptops can easily get stolen, they need recharging from time to time, some find it difficult to use the laptop keyboard and inbuilt mouse, and they are even expensive to buy and to repair. They also have limited expandability and docking stations. Laptops are more subject to wear and tear due to portability. They can also be stolen easily.

e. **Netbook Computer:** These are smaller versions of laptops, they can almost fit in a hand and do not have optical devices (CD/DVD drive) on them. Their benefits and problems are similar to those of laptops. However, they are cheaper and they have a weakness that they do not have optical devices.

f. **Tablet Personal Computers:** Type of notebook that accepts input from an electronic pen
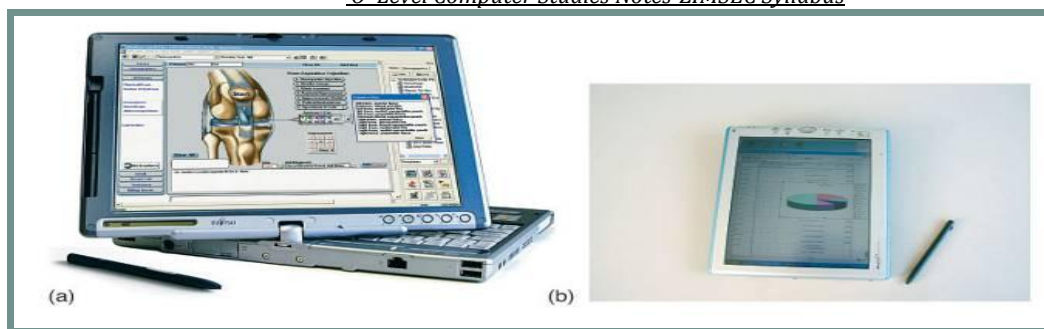
Tablet PCs (a) Slate model   *(b) Convertible model*

For schools and school children, laptops have the following advantages:
-   Users can save data in their own storage area wherever they are.
-   Users can get any networked software wherever they are.
-   School needs fewer printers.
-   Users do not need to keep using the same machine.
-   Users can access school intranet from anywhere.
-   Users can access Internet from anywhere.
-   Users do not need to carry CD ROMs.
-   It is easier to communicate with.
-   Can email work to teachers even from home.
-   Staff can monitor students easily.
-   Students and teachers can share files and notes easily.

However, the following problems may arise:
-   Work can be hacked into more easily.
-   If no convenient network point, users cannot work.
-   It is expensive to buy many network cards.
-   If server goes down users cannot work.
-   Students can use Internet inappropriately, for instance watching pornography.
-   Viruses can be downloaded easily.
-   Costs of updating or replacing server are high.

*__NB__: - **Microprocessor**: A small execution chip found on microcomputers and other devices used to process data and to control other devices. It contains registers, Control unit and the Arithmetic and Logic Unit.

- Microcomputers perform general purposes like word-processing, processing small amounts of data, playing music, etc. However, these days, microcomputers can also be used in large organisations because of improved efficiency in their usage.

2. Mini-Computers: these are in-between mainframe computers and microcomputers computers. They are bigger than micro-computers. They allow more than one user. Have more computing power. They are suitable for large business organisations like in banks where they process client accounts. They are however less powerful than mainframes. Allows several terminals with multi-tasking, few printers and larger storage location. They include mid-range server and workstations and process large amounts of data.

3. Mainframe Computers: these are large and powerful computer systems. They are mostly used in large organisations like banks and where bulk data processing is needed such as census, industry/consumer statistics, and financial transaction processing. They have the following features:
-   they can have several CPUs,
-   have very fast processor speed
-   can support multiple operating systems

- have huge storage capacity
- have huge internal memory
- can operate using time sharing or batch processing
- Allows several users and can accommodate multiple processors.
- They are very large and expensive.

Mainframe computers

These are very big in size and extremely fast. They have very large memory capacity and can be used in educational designs.

However, because of their size, they are not portable and are permanently housed in a large room. They are also expensive to maintain and to operate.

4. Super Computers: These are very powerful computers that are used to perform detailed calculations and for design purposes, for example, modelling of aircraft wings, testing bombs, etc. They are the fastest and most expensive computers

Supercomputer

*NB:- The classification of computers as micro, mini, mainframes and super computers have become blared due to recent technological advancements since a microcomputer can now perform all functions that were believed to be for mainframes.

Type	Size	Cost	Commonly used
Supercomputer	Biggest	Most expensive	Government
Mainframes	Giant	expensive	Hospitals, Airline reservation
Minicomputer	Small	Cheap	Businesses, Colleges
Microcomputers	Smallest	Cheapest	Homes

Summary: Classifications of Computers

Classification of computers can also be made relating to the use of the computer, as follows:

(a) General Purpose Computers: - these are computers that can be used to perform a number of functions like playing music, playing games, payroll processing and so on.

(b) Special Purpose Computers: - These are computers that are designed to perform one task only, for example, to monitor patients in hospital.

(c) **Analogue Computers**: these handle data in continuously varying form.

(d) Digital Computers: Handle data in discrete values; that is in 0s and 1s.

(e) Embedded Computers: – Refers to use of microprocessors in non-computer equipment like in cameras, washing machines, watches, etc. These are normally dedicated for a specific task they are designed for. Embedded computers are also found in household items like camera, microwave, washing machine, video recorder, fridge, sewing machine, air conditioning, electronic toys, rice cooker dish washer, Televisions, alarms, clock, radio, DVD players, etc.

Microprocessor controlled devices have the following advantages:

(a) To Manufacturer:
- Fewer breakdown and repairs. They are therefore easier to repair and service
- It is cheap as there are fewer parts to assemble
- Reliable
- Improve quality control

(b) To Customers
- Robust and therefore fewer repair bills
- Low power consumption
- Cheap to buy
- Faster processing
- More versatile
- Efficient since they can be dedicated to a specific task

Advantages of using computers
- ✓ They process data at very high speed, thus large volumes of goods can be produced.
- ✓ Computers are very accurate in making calculations and thus ensure that no calculation errors occur.
- ✓ Computers are very reliable to use since they rarely makes mistakes.
- ✓ Computers store large volumes of data for a long period of time.
- ✓ Computers cut labour costs as they can perform duties that need many people. They replace humans and thus cut labour costs on wages, medical aid, retirement benefits, leave payments, etc.
- ✓ Computers can work for 24 hours a day with no complains as humans. They do not get tired.
- ✓ Computers create employment for the community, for example, computer teachers (tutors), programmers, computer technicians, database administrators, etc.
- ✓ High quality goods are produced using computers.
- ✓ Ensures efficient, easier and faster communication through the internet.

Disadvantages of using computers
- ✓ Continuous usage can lead to health problems like Repetitive Strain Injury (RSI), back ache, eye problems, etc.
- ✓ Lead to increase in computer crimes like computer fraud, hacking, music and software piracy, data theft using computers, identity theft, sending of viruses, etc.
- ✓ Can lead to unemployment since computers can replace human labour as in car assemblies.
- ✓ Expenses related to repairs, maintenance and safety can be high.
- ✓ They only work when there is electricity.

NB*

Computer crime: *the use of computer to perform unlawful activities, e.g. piracy, hacking, etc*

Software piracy: *illegal copying, selling and buying copyrighted software without certification.*

Hacking: *Obtaining unauthorised accessed to protected and secure computer systems or network, usually using intelligent methods like cracking passwords*

Computer fraud: *improper electronic transfer of funds from one account to another using computers*

Copyright: *A document granting exclusive right to use, publish and sell software, musical or artistic work.*

End-user: *A person or organisation who are the final beneficiaries of a program or a device like a computer.*

Factors to Consider When Buying A Computer

-Hard disk storage capacity: Affects the volume of data that can be stored by the computer.

-RAM size: affect the number of programs that can be run on the computer and the overall speed of the computer. The bigger the RAM size the better.

-Processor Speed: Determines the amount of data that can be processed at a given period of time. The processor speed can be affected by clock speed, word size (16, 32, 64, 128 bits), bus size.

-Application intended for: what the computer will be used for, general purpose or specialised purpose.

-Method of operating the computer: single user, multi-access, etc.

- Number of Input and output devices it can handle.

ELEMENTS/COMPONENTS OF A COMPUTER SYSTEM

The main/major elements (components) of a computer are illustrated on the diagram below; namely **Input Devices, Storage Devices, Processing Device and Output Devices**.
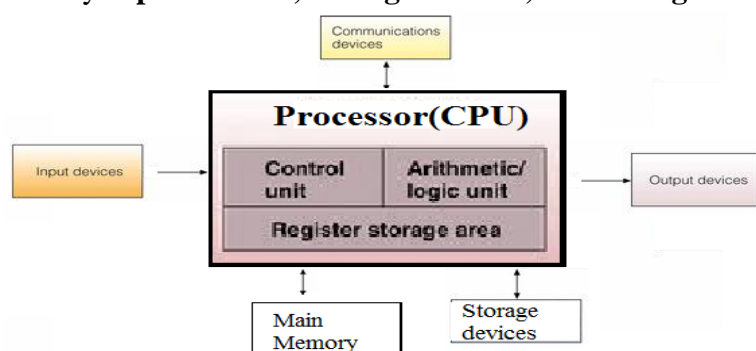
NB: Internal Components of a computer: refers to the components of a processor, which are Control Unit, Arithmetic and Logic Unit, Registers and Clock

Internal components can also include components enclosed inside the CPU casing such as; buses, fans, memory (RAM and ROM), etc

Hardware: These are parts of a computer that exits in physical form, for example mouse, keyboard. Hardware refers to tangible devices of a computer. Hardware is grouped into: **Input Hardware, Processing Hardware, Output Hardware, Storage devices and communication hardware.**

Input Hardware

These are devices used to enter/feed data into the computer, for example mouse and keyboard. Below are some of the input hardware and their uses:

(i) Keyboard: It is a device used to enter data and instructions into the computer by typing. It is a manual input device. It is similar to the traditional typewriter. It is used to enter alphabetic letters (A-Z-both lower case and upper case), numbers (0-9, positive and negative) and other special characters like the %, $, coma, ?, and the space. Keyboard entry of data is manual and its excessive use without breaks will cause **Repetitive Strain Injury (RSI).**

*NB: - A **character** is any symbol, digit or letter that can be entered into the computer, eg. $, %, 5, h, etc. These characters can be numeric (numbers 0-9, positive and negative), alphabetic (letters A-Z, both lower and upper case), alphanumeric data (a combination of both numeric and alphabetic characters) and special characters (space, $, >, etc.).

*NB: - **Control Character**: - Refers to non-printable character code or number in the character set that do not represent a written symbol, e.g. carriage return, tab key, etc. These are mostly used in peripheral devices control and for communication purposes, for example, carriage return, tab or backspace; and others typed by depressing a key and the control key at the same time.

Standard keyboard

Keyboards can be of the following types:
   (a) **Concept keyboard**: uses icons or phrases instead of standard letters, e.g. they can have the following keys: %, tax, CH, Total, etc. Most are faster for making menu choices. They have fewer keys. Mostly popular for use in bars, supermarkets, fast food restaurants, etc. They are quick and easy to use. They are also waterproof. The keys are tamper proof.
   (b) **Braille keyboard**: Suitable for the blind.
   (c) **Standard keyboard:** this is the normal, also called Qwerty keyboard.
   Advantages of standard keyboards:
   - Most people find them easy to use
   - Enable fast entry of text data
   Disadvantages of standard keyboards
   - They are manual and therefore slower than most automatic entry methods
   - Errors are very common using keyboards.
   - Can be difficult to use for others.
   - Take up valuable desk space as they are large.

   (d) **Numeric keypads:** mostly used to enter numbers only. Used on ATMs, to enter PIN and amount to be withdrawn. Also found on cell and telephones, Chip and pin devices, and on Electronic Point of Sale terminals (EPOS). They are faster in entering numeric data as compared to standard keyboards, very easy to carry around if found on cell phones. However, they have very small keys which can be difficult to use. It is difficult to use them for entering text data.

(ii) Mouse: It is a pointing device used to enter data and instructions into the computer by clicking. A mouse has either one, two or three buttons. A mouse can be cable or wireless. The mouse is also used to:
   - Select options from a menu
   - Position the cursor when editing text/typing
   - Select an object for drawing and for editing diagrams
   - Select icons/text to be formatted, deleted or edited.
   - Control movement of pointer on the screen.

Mouse

It can also be used for pointing and selecting items. **Clicking** is the process of pressing and releasing the mouse button.

Advantages of mouse
- It is a fast method of entering data and for selecting items as compared to the keyboard.
- It is faster to move cursor around the screen using a mouse than a keyboard.
- Usually supplied with the computer and so there are no additional costs.
- Very easy to use for most users.
- Take up very small area of the desk
- Very fast to switch between programs

Disadvantages of mouse
- Needs a flat surface on which to operate
- Can be easily stolen or vandalised
- Some people find it very difficult to use

(iii) Touchpad

These are pointing devices used on laptops, where one moves a finger to control the pointer on the screen. Their uses are similar to those of mouse. They aid portability since they are attached to the whole computer system. Can also be used where there are no flat surfaces available. However, they are difficult to use, e.g. when doing drag and drop.

(iv) Scanner: an input device used to convert images from paper (hard copy) into electrical signals for input into the computer.

Scanners

The images can then be edited, printed or saved. Mostly used to scan pictures, photographs, etc. they can use OCR, convert to Word or pdf format directly.

Flatbed scanners have the paper placed on top of them, in a similar way to a photocopier. These are more expensive than hand-held scanners but they are usually able to produce higher resolution images. They are very accurate in scanning. Images are stored for later editing. Quality of scanned image can depend on the resolution of scanner.

(v) Digital Camera: A device use to capture photographs, films, videos or a combination of both for entry into the computer where they can be edited.

- no film is needed (saves costs for purchasing films and developing the film)
- Unwanted images can be deleted straight away

- Images are already digital and therefore can be transferred to a computer for editing immediately,
- Easier and faster to upload photos to the computer
- Produce better quality images than the traditional camera

However:
- Images need to be compressed
- Needs those who are computer literate to use it efficiently

(vi) Touch Screen: A screen display on which you could enter data by pointing/tapping with a finger on intended option. Used on **(ATMs)-Automated Teller Machines**, cell phones, computers, etc.

Touch screen

A touch screen is both an input and output device.
A touch sensitive visual display unit (VDU) or screen has a grid of light beams or fine wires criss-crossing the screen that are used to detect touch. Many mobile phones use touch screens and do away with the keypad entirely. They're often used on cash machines and in shopping centres too. Touch screens are robust, easy to choose options. Faster to make selections. User friendly (less training needed). Tamper proof. However, they have limited number of options, leads to RSI, screen can get dirty by constant touching.

(vii) Magnetic Stripe Readers

Are devices to read information on the magnetic strip found on credit cards. The stripe contains information like account number, sort code, expiry date and start date.

Uses: used to read debit and credit card data on ATMs and EFTPOS terminals. Also used to read security cards for entry into buildings, hotel rooms, etc.

Advantages: very fast data entry. Error free data entry since no typing is involved. Information on magnetic stripe is secure since no human can read it. Can prevent access to restricted areas. Magnetic stripes are not affected by oil, water, etc. there are no moving parts and therefore are robust.

Disadvantages: if the magnetic stripe is damaged, all data is lost. They do not work from a distance, need contact with the reader.

(viii) Joystick: A device specifically used for playing games. Can be used to control pointer on screen by gripping the stick when making selections. Used also in flight simulators.

Two types of joystick

It can be an alternative to a mouse. It consists of a base and a stick perpendicular to the base. The stick can be moved in any direction, enabling the user to move an object around the computer screen. A joystick can perform a similar function to a mouse or trackball, but is only commonly used for playing games, controlling aircraft, controlling motorised wheelchair.

In construction, joysticks are used to control machinery such as cranes.

Advantage: Easier to navigate round screen, control is in 3-dimension.

(ix) Tracker ball: It is an input device with a small ball that can be moved by passing the palm of your hand over it. This will move an arrow on the screen and therefore can replace a mouse.

Tracer ball

It is used to draw designs and to select options from menu. Used as an alternative to a mouse. To operate it the user rotates the ball which moves the pointer on screen. They are particularly easy to use for those with limited movement in their hands and are often used in Computer Aided Design (CAD) for their increased precision over a mouse.

Advantages of trackball
-   It is stationery and therefore do not need a flat surface to move on
-   Less likely to get damaged than mouse
-   Less tiring as less movement is needed
-   Can be useful in laptops

Disadvantages
-   Rolling the ball is less effective than using mouse
-   Can be difficult to control
-   Not supplied as standard device, so extra cost is incurred
-   Muscles can be strained due to repeated movement

(x) Remote Control

Device used to control the operation of other devices remotely by using infra-red signals. Has button to select options, e.g. TV stations, volume, etc.

Uses
-   Used in home entertainment devices like TVs, DVD players, HIFIs, etc
-   Remote controls for multimedia systems
-   Stop/ start machinery in industrial applications

Advantages: Allows devices to be controlled from a distance, Flexible to the disabled, safer to use in chemical processes.

Disadvantages: People arm problems/disabilities cannot use them, signals can be blocked (need a line of sight)

(xi) Microphone: It is an analogue input device that recognises human voice for data entry into the computer.

Microphones are used to input sound. In computing, they can be used with voice recognition software and a word processing application to enter text. Webcams commonly have microphones built-in too.

***NB**:-An **analogue device** is a device that recognises data in continuously varying form, e.g. microphone, wall watches (with minute, hour and second hand), fuel petrol gauge, speedometer, etc.

A microphone is used in **voice recognition systems**. These are computerised systems that allow users to communicate with the computer by talking (voice input). **Such systems have the following advantages:**
-   The systems are over 90% accurate.

- They are appropriate for the handicapped, especially those without hands.
- They are very fast in entering data and in giving instructions to the computer.
- They are speaker independent.
- They can recognise natural language.

Disadvantages:
- Older systems are speaker dependent.
- They allow the user to speak slowly, using specific words that were programmed for it to understand.

NB: Multimedia speakers, sound cards, a microphone and voice recognition software are needed in voice recognition systems.

(xii) Light pen: A ballpoint shaped device used to enter data by writing on an ink pad. It is also used to make alterations on the screen to the drawings, to write directly on the screen and to select commands.

Light pen

(xiii) Kimball Tags: These are punched cards with a magnetic strip which contains details of a product, mostly clothes in a shop.

(xiv) Graphics tablet: Devices used to provide interface for drawing on the screen and links with the light pen. Can also be used with a stylus. Can be used for drawing

(xv) Webcam: A digital video camera designed to take digital photographs and transmit them over the internet or to the computer. They do not have own memory. Laptops have their own web cam.
Uses: viewing each other when chatting on internet. For video conferencing. For taking personal images.
Advantages: can be left on and only activated when required. People can see each other when chatting.

(xvi) Sensor: an input device that automatically records physical data by sensing the environment it is supposed to record, e.g. humidity sensor.

(xvii) Magnetic Stripes: Magnetic stripes can be seen on train tickets or bank or credit cards.

(a) Card with magnetic strip   *(b) Magnetic strip reader*

These stripes hold a small amount of data (64 characters) and can be read by a magnetic stripe reader (card reader) that is connected to a computer system. These provide a quick and accurate way of entering details into a computer system and are simple to operate.

(xviii) Smart Card Readers: Similar to magnetic strip readers except that they are used to read data stored on a chip. Most bank cards and credit cards are now *smart cards*. Also used on royalty cards, ID cards, electronic passports and transport passes.

Cards have their own processor and memory that can hold up to 64KB of data. The data that is stored can be updated and the processor can process simple programs.

Smart card

- Smart cards are simple to produce
- Not easily damaged
- Store a fairly large amount of information
- Automatic input devices, reduce paperwork

However:

- Data can be changed by magnetic fields
- The strip can be damaged by scratching
- Limited storage capacity
- Not very secure as thieves can alter the data.

(xix) Barcode Reader: These are devices at **Electronic Point of Sale terminals (EPOS)** that read barcodes on products for automatic data entry into the computer. Mostly used in library systems, luggage handling systems at airports, warehouse stock control, etc.

Barcodes

Barcodes are numbered vertical lines and spaces of varying size on products that provide data for such a product to the computer when read by barcode readers.

If the barcode reader fails to read the barcodes, data is entered manually through the keyboard by entering the numbers below the barcodes.

Barcodes have the following advantages:

- They are cheap and easy to use.
- They are very accurate in entering data.
- They are a very fast means of entering data since they are an automatic data entry method.
- Customers can be served quickly.
- Automatic re-ordering of goods in supermarkets is possible.
- Automatic stock taking is possible.
- Need for fewer people in the stores thereby cutting labour expenses.
- Out of date items can be automatically identified.
- There is no need for supermarket workers to remember prices.
- It becomes easier to do price changes.

Information found on barcodes includes:

- Product name, Check digit, Product number, Country of origin, Manufacturer's number, Weight.

***NB**:-The **PRICE** of an item is **NOT FOUND** on the barcode.

How does the computer system check that the barcode has been read correctly?

Either the computer performs the following:

Calculates the check digit; remainder = 0 if barcode has been read correctly OR uses the weights and modulus 11 and use remainder

Areas where barcodes are used:
- Library book systems
- Passport and ID card systems
- Equipment checking systems
- Automatic stock taking in supermarkets

(xx) Video digitiser

A video digitiser takes an image from a video camera or television and digitises it so it can be read by, and stored on, a computer. Video sequences captured using video digitisers are often used in multimedia presentations.

(xxi) Stylus: device used to write on sensitive pads or screen for data entry into the computer. Often purchased with touch screens.

Document Readers

These are devices used for entering data automatically into the computer by reading through documents. These include:

(i) Optical Mark Recognition (OMR): The Optical Mark Readers use light sensitive devices to sense pencil marks on a piece of paper for automatic data entry into the computer. Light is reflected from the document onto the Optical Mark Reader which records the output. It then records low intensity/zero intensity at certain points. OMR is mostly used in marking **multiple choice exams** at ZJC and 'O' Level, reading pupils' registers, playing lotto, etc. An Optical Mark Reader is the device that is used for automatic data entry in OMR systems.
- OMR is fast in entering data
- It is also accurate and reliable in entering data.
- Has better recognition than OCR
- Can be prepared where data originates, without machines
- Errors can be corrected easily

However:
- Mark readers are relatively slow
- Verification of data is difficult
- Document may be difficult to design
- Forms must be completed clearly for data to be recorded accurately
- Papers need to be clean

(ii) **Optical Character Recognition (OCR):** It is the use of light sensitive devices to recognise alphabetic characters and numbers on a sheet of paper for automatic data entry into the computer. Mostly used by insurance companies, in billing systems and processing of Bank Giro-forms. An Optical Character Reader is the device that is used for automatic data entry in OCR systems. It recognises printed or even hang written test for input into the computer
- Can convert large amount of text into digital form at once
- Less tiresome since it is an automatic data entry method
- Faster in entering text into the computer
- Accurate in data entry

However:
- A lot of data entry errors can be found
- May not work well with tables and diagrams
- Do not work well with handwritten text

(iii) **Magnetic Ink Character Recognition (MICR):** A method of automatically entering data into the computer by reading characters on documents past a magnetised field with iron oxide, e.g. reading numbers on the bottom of a cheque.
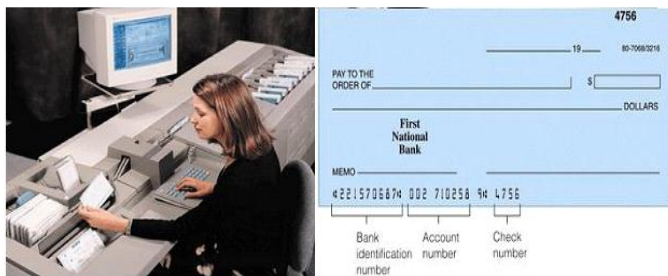
Magnetic Ink Character Recognition (MICR) Device (b) Cheque

Advantages of using magnetic ink on cheques include:
- Bundles of cheques can be processed very quickly.
- It is very difficult to forge a cheque.
- The ink can be read by the reader even if the cheque gets marked or dirty.

A Magnetic Ink Character Reader is the device that is used for automatic data entry in MICR systems

- MICR provides high level of security to data
- Automatic and therefore faster data entry
- Document can still be readable even if folded

However;
- Readers and printers are relatively expensive
- The system can only accept limited characters
- Very expensive data entry method

Factors to Consider When Purchasing Hardware

The following must be considered:
- Volume of data to be handled.
- Number of users.
- Location of user (in one office, separate office or in completely different locations).
- Type of users (used by the public or by technical specialists).
- Nature of the system (batch, online, etc).
- Security features.
- Software type, etc.

Output Devices

These are devices used to display and produce data and information held inside the computer, for example: screen, printer and graph plotters. These are described below:

(i) Printers: A printer is a device that is used to produce hard copies of data held in the computer. Hardcopy is a document printed on paper, e.g a printed school report, a printed letter, etc. Output from the printer appears as displayed on the computer screen, thus What You See Is What You Get (WYSIWYG).

Types of Printers

Printers can be classified into **impact and non-impact printers**.

(a) Impact Printers: these are printers whose write heads hit ink ribbon against paper during printing, e.g. dot matrix printer, chain printer, daisy wheel printer, drum printer, etc. Thus, there is contact between the paper and the write heads during the printing stage. Examples include drum printers, dot matrix printers, daisy wheel printers and chain printers. Impact printers have the following advantages**:**
- they are very cheap to buy.

- They are cheap to repair and to maintain.
- They can use continuous paper.
- They are economic in terms of ink usage.

dot matrix

However, Impact printers have the following disadvantages: They produce a lot of noise. They are very slow in printing since most are line printers. They produce poor quality printout.

Dot Matrix printer

- Produces NLQ (Near Letter Quality) output, in form of small dots.
- They are robust
- Less likely to be affected by dust
- Can print multi-part stationery
- Purchasing and running costs are very low

Weaknesses

- Low resolution
- Noisy
- Slow printing speed: this is because they can be character based or line based printers.

Daisy wheel printer

- Uses a print wheel to produce characters
- Can print about 100 characters per second

(b) Non-Impact Printers: These are printers that do not produce contact between paper, write heads and ink cartridge during printing. Non-impact printers include: inkjet printer, laser printer, thermal printer, etc.

Laser printers

Most of the printers use light and are therefore called laser printers.

LaserJet printers

The advantages of laser printers are as follows**:**

- They print at very high speeds since they are page printers.
- They produce high quality text and graphics.
- They produce less noise than dot-matrix printers (they are quiet in their operation).
- Have paper trays both for input and output and therefore need no supervision once setup.
- The toner is not water-soluble

The disadvantages of laser printers are as follows:

- they are very expensive to buy,
- they are large and therefore take up a lot of desk space,
- they are quite complex and therefore repair bills can be very high,
- Cannot be used with continuous stationery since they are page printers.
- Toner is toxic/poisonous and therefore should be disposed of carefully after use.

Inkjet printers

Uses print head to propel droplets of ink on a sheet of paper.

Advantages:

- relatively high resolution
- Good colour production
- Low cost/heap to buy
- Usually small size

Disadvantages
- Slow printing speed
- Ink is expensive
- Has a water soluble ink which may be spilt
- Running costs are expensive

*NB: - Printers can also be classified as **page printers** (these print one page at a given time and are therefore faster), **line printers** (print one line at a time, very slow) and character printers (print one character at a time).

Factors to consider when purchasing a printer:
- Price
- Printing speed
- Reliability and easiness of maintenance
- Print quality
- Range of capabilities
- Noise level
- Compatibility with computers

(ii) Screen / Monitor: it is a television shaped device used to display contents on the computer as soft copy. Soft copy refers to data viewed on the screen. The screen can also be called the Visual Display Unit (VDU). The screen can differ in terms of resolution, that is low resolution screens display less number of dots per inch on the computer and therefore the display will be of poor quality. High resolution monitors are needed mostly in graphics packages where colour and many dots per inch are needed.

Monitors are of three main types:
- **LCD (Liquid Crystal Display)**
  Relatively thin and do not use a beam of electrons. They easily fit on walls and desks, light weight, compact and can fit on laptops, little light is reflected, absence of flicker on the screen. However, images can be viewed from fewer angles, can display limited range of colours.
- **CRT (Cathode Ray Tube)**
  These are the older and bulker versions. To display content, an electric gun fires a beam of electrons from the rear of the CRT. They are cheap, images can be viewed from a wider angles, and has a wider range of colour and brightness. However, they are bulky and difficult to fit on a desk, they are heavy and difficult to mount on walls, and too much reflection can affect eyes.
- **Plasma Display Panels:**
  Flat panel display used for television displays

Advantage of Monitors
- Its output is immediate and visual
- High speed of display
- No noise
- No wastage of paper
- Can display text, graphics, etc

Disadvantages
- When the display changes, the previous output is lost.
- Needs a separate device to produce hardcopy

(iii) Graph Plotter: This is a device used to produce high quality drawings in various paper sizes and is used in **Computer Aided Design (CAD).** A plotter can be used to produce high quality, accurate, A3 size or bigger drawings. They are usually used for Computer Aided Design (CAD) and Computer Aided Manufacture (CAM) applications, such as printing out plans for houses or car parts. They print sharper and more precise drawings.

Graph plotter

(iv) Data projector
An output device that uses lenses to project intense light on the wall. Can be multimedia projector and offer wider/ bigger screen display on the wall. Ideally the surface should be a whiteboard. Suitable for presentations to a wider audience. However, it is more expensive to buy and has a fragile bulb.

(v) Speakers: produce sound from music files on the computer. They are used in conjunction with multimedia files.

(vi) Braille Printer: prints Braille which is readable to the blind people.

(vii) Actuators: these are output/control devices which turns on or off some devices in control systems. Some of the control devices include electric heater (supplier heat), electric motor (provide movement/rotation), motorised pump, buzzers, lights, heaters, actuators, etc

Processing Device
A device used to convert and to manipulate data as per user requirement. The sole processing device of a computer is the processor, which is inside the Central Processing Unit (CPU) casing. Processing involves sorting of data, updating records, searching certain records, adding a sequence of numbers, and others.
 The processor has the following functions:
- It controls the transmission of data from input device to memory
- It processes the data and instructions held in main memory
- It controls the transmission of information from main memory to output device.
- Controls the sequence of instructions,
- Give commands to all parts of the computer,
- Fetches the next instruction to be executed
- Decodes instructions
- Executes decoded instructions

Microprocessors

Most of the computers have micro-processors (small execution chip found in microcomputers). With MS-DOS (Microsoft Disk Operating System) computer chips progressed from 286, 386 and 486 processors. Intel Corporation then developed Pentium processors, ranging from Pentium 1, Pentium 2, Pentium 3, Pentium 4 and so on, with each processor being faster then the preceding one. Pentium 4 processors have a speed of about 2.6 GHz. Newer chips are faster in processing.

The speed of a processor determines the speed and function of a computer. Until the 1980s, most computers had one processor, but recent ones have two or more processors (called co-processors), those with two processors are called dual processors. Two or more processors share loads and therefore perform operations faster. The speed of a computer is also determined by the **clock speed** for each microprocessor. This speed is measured in Megahertz (MHz). The general structure of the CPU or Processor is as illustrated below:
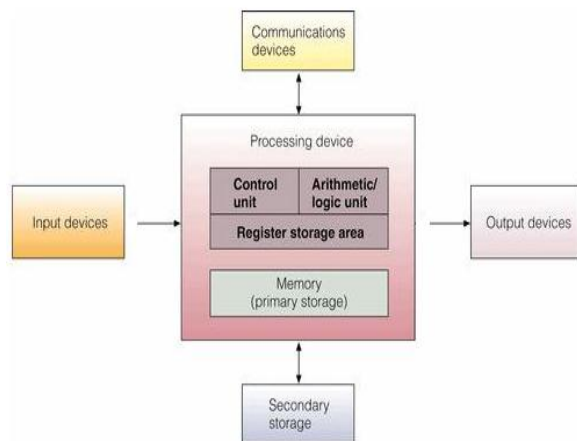
The processor comprises of: Arithmetic and Logic Unit (ALU) and the Control Unit (CU) and Registers

(a) Arithmetic and Logic Unit (ALU)
- Carries out arithmetic operations like add, subtract, divide, etc.
-Performs logic operations, like AND, OR,..etc
(b) Control Unit (CU)
- It coordinates and controls all hardware operations,
- It carries out the Fetch-Execute Cycle.
(c) Registers: High-speed storage area in the CPU used to temporarily hold small units of program instructions and data immediately before, during and after execution by the CPU.

NB: Memory (Main memory): Stores programs and data for programs currently running on the computer. Main Memory is very close to the processors and therefore the two can coordinate their activities very fast.
- **ALU** operations on data are first loaded into the **accumulator register**, a memory which stores instructions, data being processed and results of an operation.
The function of the microprocessor is to fetch, decode and execute instructions. This is also called the Fetch-Execute cycle.

The Fetch-Execute Cycle
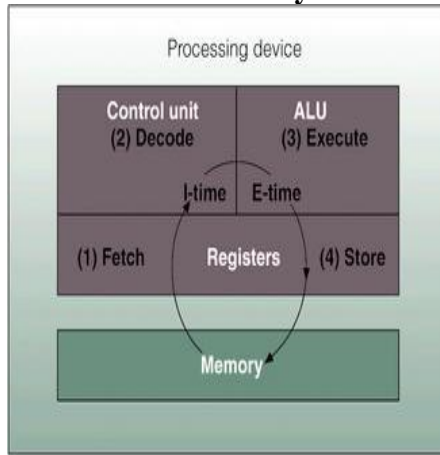
The Fetch-Execute Cycle

Step 1. Fetch instruction: In the instruction phase, the computer's control unit fetches the instruction to be executed from memory. Microprocessor gets software instruction telling it what to do with data.

Step 2. Decode instruction: Then the instruction is decoded so the central processor can understand what is to be done. Microprocessor determines what the instructions mean.

Step 3. Execute the instruction: In the execution phase, the ALU does what it is instructed to do, making either an arithmetic computation or a logical comparison. Microprocessor performs the instruction.

Step 4. Store results: Then the results are stored in the registers or in memory.

Step 3 & 4 are called the execution phase. The time it takes to complete the execution phase is called the EXECUTION TIME (E-time).

After both phases have been completed for one instruction, they are again performed for the second instruction, and so on.

Buses

- A bus is a pathway through which data and signals are transferred from one device to another in the computer system.
- They are a set of parallel wires connecting two or more components of the computer.
- Buses can be internal or external.
- Buses can be generally referred to as **system** bus and this connect the CPU, memory and I/O devices.
- Each bus is a shared transmission medium, so that only one device can transmit along a bus at any one time.
- Multiple devices can be connected to the same bus

The main types of buses are:

- Data bus:

- Used for carrying data from memory to the processor and between I/O ports.
- Comprises of either 8, 16, 32 or 64 separate parallel lines
- Provide a bi-directional path for data and instruction's between computer components. This means that the CPU can read data from memory and input ports and also send data to memory and output ports.
- The width of the bus determines the overall system performance. For example, if the data bus is 8 bits wide, and each instruction is 16 bits long, then the processor must access the main memory twice during each instruction cycle

- Address bus:

- Used for transferring memory addresses from the processor when it is accessing main memory
- They are used to access memory during the read or write process
- The width of the address bus determines the maximum possible memory capacity of the computer.
- This a uni-directional bus (one way). The address is send from CPU to memory and I/O ports only.

- **Control bus**:

• The purpose of the control bus is to transmit commands, timing and specific status information between system components. Timing signals indicate the validity of data and address information. Command signals specify operations to be performed. Specific status signals indicate the state of a data transfer request, or the status of request by a components to gain control of the system bus

• This is a bi-directional bus used for carrying control signals (Signals can be transferred in both directions).

• They carry signals to enable outputs of addressed port and memory devices

• Control signals regulate activities on the bus.

• Control buses transmit command, timing and status information between computer components.

Fan
A fan is used to cool the processor. It blows away hot air so that the processor remains cool.

Storage Media
These are devices used to store data and programs for future use.

Methods of storing data:
Refers to ways files and records are stored on a storage media, that is the arrangement of data. These include:
- **Serial Storage:** Data is stored as they occur without following any order, as on magnetic tapes.
- **Sequential Storage:** Data is stored using a predefined order, either in ascending or descending order of a key field, as occurs on magnetic tapes.
- **Direct (Random) Storage:** Data is stored in a random way using an index, as on diskettes, hard disks, CD-ROMs, etc.

Methods of Accessing Data
These are methods used to retrieve data held on storage media. These include:
(1) Serial Access: Data is retrieved in the order it is stored, reading files one after another from the first until the required data is found in an unsorted list of records. It is very slow and time wasting in accessing records far away from the first position but is faster to access data at first position of the disk. It is used in magnetic tapes.
(2) Sequential Access: Data is retrieved in the order stored, from the first until the required data is found, using a key field in a sorted list of records, as in magnetic tapes.
(3) Direct (Random) Access: Data is retrieved by going directly to the needed file, as applied in hard disks, diskettes, CD-ROM, DVD-ROM, Memory Sticks, etc. It is a very fast method of accessing data.

Storage Capacity
Refers to the amount (volume) of data a device can store. The following storage measurements can be used:
Bit: Short for Binary Digit. The smallest unit of data a computer can store, either a 1 or a 0.
Nibble: refers to half a byte, that is, a group of 4 bits.
Byte: a group of 8 bits representing a character, e.g 01000011. For example, the letter C is represented by the byte 01000011.

Size	Equal to
8 bits	1 byte
1024 bytes	1 kilobyte
1024 kilobytes	1 megabyte
1024 megabytes	1 gigabyte
1024 gigabytes	1 terabyte

Kilobyte (KB): this refers to 1024 bytes.
Megabyte (MB): 1 MB is equivalent to 1 048 576 bytes.
Gigabytes (GB): 1024 megabytes (approximately 1 billion bytes)
Terabytes (TB): refers to 1 099 511 627 776 bytes (approximately 1 024 GB)

*__NB__:-**Formatting (initialising)** a disk: this is the process of creating new tracks and sectors on the disk that will be used in storing data. When a disk is formatted, existing tracks and sectors are destroyed, including the data stored on them, and new ones are created. After formatting, the disk will be blank. Formatting is done using the FAT or the NTFS file system. Storage media is grouped in **primary storage** and **secondary storage**:

1. Primary Storage (Main Memory, Main Store, Immediate Access Memory, Internal Storage)

Refers to a group of chips inside the processing unit where data and instructions are held whilst processing takes place. Main memory is very fast and reliable to use. Data is instantly accessed due to its proximity to the processor.

Main storage is used for:
- Storage of instructions waiting to be obeyed by the computer.
- Storage of programs currently being run on the computer.
- Storage of data currently being processed.
- Storage of input data before processing.
- Storage of output data, waiting to be saved or output to the printer.
- Acts as a working area for data currently being processed.

Main memory is grouped in to **RAM** and **ROM**.

(a) RAM (Random Access Memory):

A memory chip inside CPU casing used to store data and programs temporarily during processing.

RAM Chips

The uses of RAM are:
- To store programs currently running on the computer.
- Storage of data being processed in the computer.
- Storage of output data.
- Acts as a working area for data and programs.

RAM is **volatile**, which means that it loses its contents when power is switched off. RAM is in two forms; that is, dynamic and static RAM. **Static RAM** is a Random Access Memory chip whose contents do not change as long as there is continuous power supply. **Dynamic RAM** is Random Access Memory chip whose contents can be lost even if there is continuous power supply. Dynamic RAM needs to be refreshed to prevent loss of data.

The size of RAM also affects the speed of operation of a computer and the number of programs that can be run on it. RAM size can be 16 MB, 32 MB, 64 MB, 126 MB, 256 MB, 448 MB, 1 GB, etc. The bigger the RAM size, the better the efficiency of the computer and the bigger the number of programs it can run at a given time.

(b) ROM (Read Only Memory): ROM is a semi-conductor circuit (chip) whose contents can only be read from and cannot be erased or modified. ROM contents are fixed during manufacturing, that is, they are hard – wired. These contents can only be read from and cannot be modified.

The uses of ROM are:
- Stores the Basic Input-Output System (BIOS-refers to software that test hardware at start-up, starts the operating system and support data transfer between devices.) of the computer.
- Stores control programs for the operation of the computer and its peripherals.
- Stores translator programs.

ROM is grouped into:

Programmable Read Only Memory (PROM): This is a ROM chip whose contents can be changed but only once. It is re-programmable only once.

Erasable Programmable Read Only Memory (EPROM): This is a Read Only Memory chip whose contents can be erased and modified several times.

Electrically Erasable Read Only Memory (EEPROM): This is a Read Only Memory chip whose contents can be erased and modified several times using electricity.

*__NB__:- __Firmware (microcode)__:-refers to coded instructions that are stored permanently in read-only memory, for example BIOS.

Difference between RAM and ROM

	RAM	ROM
1	Is Volatile	Non-volatile
2	Stores user's programs and data during usage	Contains boot-up file and BIOS
3	Needs top-up (to be upgraded/increased)	Do not need top-up
4	Stores data temporarily	Stores data permanently
5	Writable Memory	Read Only (not Writable)
6	Has bigger storage capacity	Has less storage capacity

Secondary Storage (Backing Storage/Auxiliary Storage/External Storage)
These are devices used to store data and programs for future use outside the computer systems. It is a supplement to main storage. Backing storage is non-volatile. Backing storage is grouped into **magnetic storage, solid state and optical storage.**

Magnetic Storage
These store data on magnetised field of iron oxide and include magnetic tapes, zip drives, diskettes, hard drives, cassettes, etc.

(a) Magnetic Tapes: They are similar to a normal cassette tape in shape. They store data in serial and sequential order. They are mostly used to backup data. Their storage capacity can

be up to 20 GB. Data is also accessed in serial or sequential order. They can be used as off-line storage media.
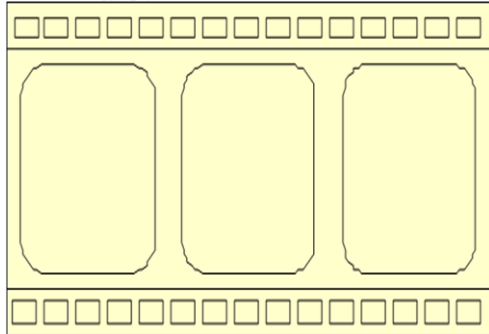
Magnetic tape

Magnetic tapes have the following advantages:
- Data can be arranged in an ordered sequence.
- They are re-usable, that is can be overwritten several times.
- Suitable for high hit rate processing systems like payroll, billing systems, etc.
- They last for a very long period of time, and thus can be used to keep historical records.
- They are very cheap to buy.
- They store very large volumes of data, of up to 20 GB.
- They are small, robust, and portable and provide low cost storage per *GB*.

However, they have the following disadvantages:
- It takes too long to find (search for) a needed record in a long list of data records. It is very difficult to update record held in a magnetic tape.
- It takes too long to update records, time wasting.
- They are prone to humid (moist) conditions.
- They are very slow to write to and read from

(b) Hard Disk (Hard Drive): These are disks used to store large volumes of data and programs, including operating systems and are resident in the CPU casing. Data is stored on tracks in a random way and data retrieval is in a random way. Hard disks can store data of up to 300 GB, but ranges from 2 GB, 8 GB, 20 GB, 40 GB, 80 GB, 120 GB, etc. a hard disk can be internal or external. External hard disks have a larger storage capacity and can be used to back-up the system

Hard disc: Internal Structure(Above) & External Appearance (Below)

Uses of Hard Disk:
- Creating backups for data.
- Storing communication and applications software.
- Storing of the operating system from which the computer will boot.
- Transferring large volumes of data from one computer to another.

**Hard disks have the following advantages:**
- It is easier to access data stored on hard disks.
- They have a long life span, of about 5 years or more.
- Provides direct access to data.
- It is easier and faster to update data on hard disks.
- They are more robust.
- Have large storage capacity, about 300 GB or more.
- Very reliable to use

Disadvantages of Hard Disks:
- Are fixed inside the CPU casing and therefore cannot be repaired once damaged.
- All data can be lost if it crashes
- Can easily crush if computer is not switched off properly.
- They are expensive to buy.

(c) Diskette (Floppy Disk): A 3.5 inch and plastic magnetic disk enclosed in a stiff envelope with a radial slit; used to store data or programs. They have a storage capacity of 1.44 MB. They are used as backing storage for small volumes of data. Data is stored on tracks in a random way. Direct access to data is provided. Its features are shown below:

Diagram of a Diskette:
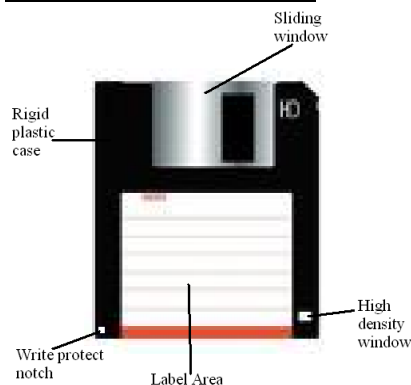
Notes on Diagram
Rigid plastic case: - protects the disk inside from damage.
Write protect Window: When it is open, data cannot be written on disk, unless it is closed. It is a method of preventing data on disk from being modified.
Disk Label: this is where the user writes some information, for example his/her name, disk contents, etc.
High Density Window: - indicates that a disk can store data on two sides, thus allowing more data to be stored on them. 1.44 MB disks are double density disks.

Uses of diskettes are:
- Creating backups for small amounts of data.
- Transferring small amounts of data from one computer to another.
- Booting up the computer in case of system failure, for system recovery.
- Storage of small programs and data.

Advantages of Diskettes:
- They are portable (easy to carry around as they can fit in a shirt pocket.).
- Conceals less electricity.
- Most are high Double Density Diskettes.

Disadvantages of Diskettes:
- have very short life span (not durable).
- Can be affected by humid conditions.
- Can easily be affected by dusty conditions.
- Can easily be damaged if placed close to the screen for a long time.
- Takes long to read data into memory than from a hard disk.
- Hold very small amount of data, 1.44 MB.

Caring for diskettes:
- Do not place them near magnetised field or near the computer screen.
- Keep them free from dust.
- Keep of dry place.
- Do not expose them to direct sunlight.

(d) Zip Drives: Similar to diskettes in shape but does not flop. Data is stored in a random way. Data is accessed in a random way. Storage capacity is 100 MB.

Advantages of Zip Drives:
- They are portable (easy to carry around as they can fit in a shirt pocket.).
- Conceals less electricity.
- Relatively cheap
- Most are high Double Density drives.
- More durable than diskettes
- Good for archiving data

Disadvantages of Zip Drives:
- Hold small amount of data of about 100 MB.
- Not as compact as USB flash drive
- Slow data transfer rates

Zip drive

Solid State Storage Media

These are storage devices with no movable parts. They are based on **electronic circuits** with **no moving parts** (no reels of tape, no spinning discs, no laser beams, etc.). Solid state devices use a special type of memory called flash memory. Examples of solid state devices include flash memory, USB memory stick, memory cards, etc. Solid state devices takes the form of solid state drives (SSD), solid state cards (SSC), solid state modules (SSM), etc

(a) Flash Memory

Flash memory is a type of **EEPROM**. Flash memory is **non-volatile** (like ROM) but the data stored in it can also be **erased** or **changed** (like RAM). Saving data to flash memory is very slow compared to saving it to RAM. If a computer were to use flash memory as a replacement for RAM it would run very slowly.

However some portable computers are starting to use flash memory (in the form of solid-state 'discs' as a replacement for hard-drives. No moving parts mean less to go wrong and longer battery life.

(b) Memory Cards

Many of our digital devices (**cameras**, **mobile phones**, **MP3 players**, etc.) require **compact**, **non-volatile** data storage. Flash memory cards provide this and come in a variety of shapes and sizes.

Memory card is like a portable hard disk that fits into personal computer card slot.

They offer direct access to data, are portable, can fit even on tablet computers like cell phones, have large storage capacity of up to 8 GB.

They can get lost easily. Virus spread quickly through them.

Memory cards

(c) Smart Cards

Many credit cards (e.g. '**chip-and-pin**' cards), door entry cards, satellite TV cards, etc. have replaced the very limited storage of the magnetic strip (the dark strip on the back of older cards) with **flash memory**. This is more **reliable** and has a much **larger storage capacity**.

Cards with flash memory are called **smart cards**.

(d) USB Memory Sticks:

These are small drives that can be plugged on the Universal Serial Bus (USB) of the CPU. Provide direct storage and access to data.

Memory sticks (or 'thumb-drives') have made many other forms of portable storage almost obsolete (why burn a CD or DVD when you can more easily copy your files onto a memory stick). Memory sticks are **non-volatile**, **random-access** storage devices.

Each of these small devices has some **flash memory** connected to a **USB interface**. Plug it into your computer and it appears as a drive. You can then add files, erase files, etc. You can use it to **move any type of file** between computers.

Memory stick

Storage capacity ranges from 1 GB, 2 GB, 4 GB, 8 GB and 32 GB.

Advantages of Memory Sticks:
- have a long life span about 3 yrs.
- Have large storage capacity about 32 GB or more.
- Provide direct access to data.
- Very cheap to buy.
- Portable since they can fit in a pocket.

Disadvantages of Flash Drives:
- Older machines have no sockets to plug in memory sticks.
- They need software/drivers installed for them to work.
- They can get lost easily.
- Virus spread quickly through them.

1. Bus: A communication line used for data transfer among the components of a computer system

2. USB: - An external bus that supports Plug and Play installation of devices. Using USB, you can connect and disconnect devices without shutting down or restarting your computer. You can use a single USB port to connect up to 127 peripheral devices, including speakers, telephones, CD-ROM drives, joysticks, tape drives, keyboards, scanners, and cameras. A USB port is usually located on the back of your computer near the serial port or parallel port.

3. USB port: An interface on the computer that enables you to connect a Universal Serial Bus (USB) device. USB is an external bus standard that enables data transfer rates of 12 Mbps (12 million bits per second).

Optical Storage Media:

Refers to devices that use light to store data on them and these include Compact Disks, Digital Versatile Disks, Video Compact Disks, etc

1. CD (Compact Disk): It is spherical disc that uses laser beam technology to read and write data. It stores data on tracks in a random way. Data retrieval is in random order.

Storage capacity is 750 MB. Writing of data on CD is done by a device called CD writer/burner.

Compact disc

Uses of compact disks:
- Transferring data from one computer to another.
- Creating backup storage for programs and data.
- Booting the computer when loading the operating system or restoring damaged system files (system repair).

Advantages of CDs:
- Provide fast and direct access to data.
- Has large storage capacity of about 750 MB.
- Produces high quality sound and pictures.
- It is a multi-media device.

Disadvantages of CDs: Can be affected by direct sunlight. Less durable. They can easily get scratched. Not so easy nor fast to save data on them

Types of CDs
1. **CD-ROM (Compact Disk Read Only Memory)** a common form of optical Disks on which data, once it has been recorded, cannot be modified.
2. **CD-W (CD-Writeable)** an optical disk that can be written upon, but only once. Often called WORM (Write Once Read Many) disks.
3. **CD-RW (CD-Rewriteable)** on optical disk that allows personal computer users to replace their diskettes with high-capacity CDs that can be written upon and edited over.

Advantages to schools of storing learning materials on a CD-ROM other than using the Internet
- No danger of accessing doubtful websites.
- Does not take as long to find required information.
- Do not have to have a modem.
- Do not need for a telephone line.
- Once CD ROM is bought there is no additional expenditure.
- Do not have to remember user id/password.
- Usually quicker to load material.
- Information on CD is more reliable

Disadvantages to schools of storing learning materials on a CD-ROM other than using the Internet
- CD ROM can be lost easily.
- CD ROM can be damaged easily. Internet is up to date while CD ROM is soon out of date.
- CD ROMs are expensive to replace and to update.
- Less information can be stored on the CD-ROM as compared to the internet.

2. DVD (Digital Versatile Disc): Are spherical in shape that can store data on 2 sides. Stores data on tracks in a random way. Data retrieval is in random order. Storage capacity is about 4.7 GB. Writing of data on DVD is done by a device called DVD writer/burner. There are several formats on the market, such as:

DVD-ROMs - read only, the data is written to them before they are sold.

DVD-R - meaning DVD-Recordable, the user can write data to the DVD once or fill it over time using multi-session.

DVD-RW - meaning DVD-ReWritable, the DVD can be written and re-written to. Unlike multi-session discs, existing data can be overwritten.

Uses of DVDs:
- Transferring large volumes of data from one computer to another.
- Creating backup storage for programs and data.
- Booting the computer when loading the operating system or restoring damaged system files (system repair)

Advantages of DVDs:
- Provide fast and direct access to data.
- Has large storage capacity of about 4.7 GB or more.
- Produces high quality sound and pictures.
- It is a multi-media device.

Disadvantages of DVDs:
- Can be affected by direct sunlight.
- Less durable.
- They can easily get scratched.

Caring for DVDs, VCDs and CDs:
- Do not expose them to direct sunlight.
- Do not touch the recording surface.
- Use soft marker for labelling and not ball point.
- Keep them free form dust conditions.

*NB: - Virtual Memory – Refers to temporary storage (on hard disk) used by the computer to run programs that need more memory (RAM) than the computer has. For example, programs could have access to 4 gigabytes of virtual memory on a computer's hard drive, even if the computer has only 32 megabytes of RAM.

COMPUTER APPLICATION

This chapter deals with the areas where computers are used, what they used for, how they are used, the advantages and disadvantages of their usage in such areas.

Computer Application in Education

i. The use Internet allows unlimited access of information on all subjects.

ii. Distance learning made easier through chartrooms, digital interactive television, CD-ROM (storage of encyclopaedia, learning materials (content)). Learning materials like the encyclopaedia can be stored on the CD ROM as it will have the following **advantages** as compared to a printed (manual) encyclopaedia:

- Cannot write to it so cannot be changed.
- Can use sound, text as well as video for students to understand better.
- Search of data is quicker.
- Can printout data conveniently.
- It takes up less space.
- Is more portable.

However, the electronic encyclopaedia has the following **disadvantages** as compared to a manual one:

- Users need a suitable multimedia computer for them to use it.
- The computer could crash and access to data will not be possible.
- Can lead to electricity expenses.
- Cannot be read in awkward locations.
- Takes time to start up the computer.
- The disk can be stolen easily.
- You can't add notes to a Recordable Compact Disk

iii. People with communication difficulties like the blind and deaf are assisted, e.g. in voice recognition systems.

iv. Computers can be used to **organise** events in schools, for example, parents' visits, timetable, etc.

v. Used to store students data, exams, teachers records, etc.

vi. Used as teaching aids in all subjects. Enables interactive teaching

vii. For marking multiple choice examinations on scanner sheets

viii. For storage of student data pertaining to subjects, teachers and subjects taken.

ix. Used as a subject for student to learn, e.g. Computer Science, Information Technology, etc.

x. Used for carrying out researches and experiments which may be dangerous for human beings to do.

xi. Computers can also be used in Computer Aided Learning (CAL) and Computer Aided Instruction (CAI).

CAI: a teaching system that operates on drill and practice principle, for instance, in teaching computers, a student is presented with a word and its meaning. The student studies it and will be asked its meaning at a later stage.

CAL: This whereby a lesson is rehearsed before the computer and then played back to the class when the teacher is not physically present. The computer is thereby used to teach the pupil. For example, the computer present a topic just like a teacher does in a lesson. Pupils are asked questions. If they fail, the lesson is repeated; otherwise a new topic will be presented. CAL has the following **advantages**:

- This system allows pupils to study at their own pace, repeating sections they do not understand.
- Material is presented in a consistent way making learning easier.
- Few teachers are required.
- Computers are endlessly patient and can repeat sections that pupils did not understand without hesitation.

xii. Used for typing and printing examination papers and keeping of student results.

Some schools have pupils who are either blind or partially sighted. Computers could be used to help these pupils to learn in the following ways:

- Use of sound (voice) output and speech synthesiser.
- Use of speech (voice) input, recognition or microphones.
- Type using large characters (large font size) on the screen.
- Use of Braille keyboards, touch screens, touch pads.
- Use of bright colours to improve visibility.
- Use of scanners to input information and output speech.
- Use of printers which give output in Braille

Xiii: Electronic Registration (e-registration) of students

xiv. E-marking of student examinations

Computer Application in Banks

Uses of computers in banks:

i. Used for **storage** of client account details like, account name, account number, address, sex, date of birth, national identification number, balance, withdrawal, deposit, overdraft, interest, etc.

ii. Used for **cash disbursement** at the *Automated Teller Machine (ATM).* An ATM is a computerised, special purpose cash disbursement machine outside banking halls used even when banks are closed. Services offered at the ATM include:

- Balance enquiry,
- mini-bank statement,
- facility to change PIN code,
- cash withdrawal, etc.

PIN (Personal Identification Number) - a secret number used by individual account holders to access bank account and get service at the ATM. The account holder needs a debit card for him/her to access bank services at the ATM.

The Account holder inserts the debit card into the hole on the ATM, which in turn request the user's PIN. The user enters the PIN and then presses enter. The ATM validates the PIN, and if it is correct, allows the user to select service required from the list of options available. If the user enters the wrong PIN for three consecutive attempts, the ATM would not eject the debit card, assuming that you are not the owner of the card and no service shall be given.

iii. Clearance of cheques: The main branch receives cheques from other branches and processes them using the batch processing method. MICR is used to read data from the cheques into the computer.

iv. Electronic Funds Transfer at Point of Sale (EFTPOS): This is a method of transferring money from one account to another electronically without handling of cash at the Point of Sale terminal in shops. The Point of Sale terminals will be online the bank's database, enabling the shop to deduct cash from the customer's account and transfer it to the shop's account. For this to occur the customer is supposed to produce the debit card, which is

wiped on the card reader which in turn requests the client to enter the PIN. Some cash back is available at the POS.

Electronic banking (e-banking): the process of carrying out all bank transactions electronically on the internet (internet banking) and by use of cell phones. This is almost similar to tele-banking.

For **Internet banking**, credit cards are required for clients to get access to the bank accounts. Data about credit cards is stored on the magnet strip and this includes: Date of issue, Bank code, Branch code, Account number, Card number and Expiry date. Information entered by a client to access banking services from home includes: Account Number, Account name and password.

In **home banking**, users can stop a cheque, enquire their account balances, transfer money between accounts, pay bills, order a cheque book, look at account transactions for a given period, request a change of pin or password, amend or create standing orders/direct debits, print statements and change personal details. It is impossible to withdraw cash or pay in cash.

In home banking, the following advantages are realised by customers:
- Do not have to waste time travelling long distances to banks.
- Do not have to spend money on travelling expenses travelling long distances to banks.
- No embarrassment of having to ask for loans face to face.
- Can do bank transactions even when banks are closed.
- Do not have to waste time waiting for a response to telephone banking.

However, home banking has the following disadvantages:
- Less personal touch is involved hence no socialisation with friends and neighbours.
- More expensive phone bills are to be paid.
- Lack of exercises as user just sits on the computer.
- Hackers can access personal details and transfer money to their accounts.
- You have to have a computer and an Internet access of which less people can afford.
- Users are unable to withdraw cash

When purchasing the goods, the supermarkets and any other shops check the following on the credit card:
- Check if the card is valid.
- Check if credit limit is not exceeded.
- Check if credit card is not reported as stolen.
- Check if expiry date has not been exceeded.

The introduction of ATMs, EFT and electronic banking, including internet banking has the following advantages and disadvantages.
Advantages to Bank workers
- Their workload is reduced, for instance the burden of counting cash and service many clients can be done the ATM.
- Reduction in mistakes, for instance counting cash and updating wrong accounts as the computers validate details during entry.
- Reduction in working hours.
- Increased salaries.
- Better working conditions
Disadvantages to Bank Workers
- Some lose their jobs due to computerisation.

- Leads to de-skilling where some jobs are taken as redundant, for example clerical jobs.
- Some workers will be transferred

Advantages to Bank clients
- Customers get faster service as they are served quickly.
- Customers save time spend in travelling to banking halls by use of cell phones and internet bank.
- Customers no longer carry around large amounts of cash as all payments are done electronically and this reduces robbery cases.
- Clients get bank services at ATMs even during public holidays, weekends and after hours.
- Customers are provided with 24 hour services.
- Customers save money used to pay travelling expenses to banks.

Disadvantages to Bank clients
- Customers can lose money through credit card fraud.
- Customers may forget their PIN and fail to get service at ATM.
- Debit cards and credit cards can be stolen and used illegally thereby customers will lose their money.
- There are cases of phantom withdrawals: unexplained cash withdrawals from bank accounts.

Computer Aided Design (CAD).

Software used in the designing and developing new products in a variety of applications both at home and on a commercial/industrial basis. Models of infrastructure like bridges are designed and tested for their strength before building actual structures on the ground. A **model** is a computer representation of a real object/process, often involving some formula that determines its behaviour, e.g. a bridge, house, etc. CAD is used in fields like:

> Aerospace, Architecture, Car/vehicle design, Construction (e.g. Roads, services, surveying, tunnels, bridges, etc.), Consumer goods (e.g. kettles, toasters, etc.), Digital circuits, Factory layouts (e.g. Ergonomics), Fashion design, Heating systems, Interior designs (houses, offices, etc.), Lighting systems (e.g. to get lighting effects at a concert), Machinery design, Plant design (chemical, nuclear, etc.), Ship building, engineering, architectural design, etc.

CAD Requirements

- **considerable processor power:** for faster processing of data and graphic handling
- **Input devices like:**
    - **Light pen**: Used to make alterations on the screen to the drawings. Also used to write directly on the screen. Can be used again to select commands.
    - **Tracker balls**: used to draw designs and to select menus
    - **Mouse**: adjust drawings
    - **Graphics tablet**: provide interface for drawing on the screen. It also links with the light pen.
- **Output Devices like:**
    - Large high resolution screens
    - Graph plotters to draw scale and full size and high quality drawings
    - High specification graphics cards

- Some systems support stereoscopic drawings where 3-D spectacles can be worn and the user sees a 3-D image.

Features of the CAD software which are used in design are:
- Can zoom, rotate, scale, and crop images

- Has a library of geometrical shapes that will be used in drawings
- Has inbuilt library of components and templates.
- Have ability for labelling and adding text
- use 2-D and 3-D modelling
- has library of parts which can be used in new drawings
- use colour fill feature
- Validation and verification of designs against original specification
- Ability to link with **Computer-Aided Manufacture (CAM)**
- Facility to calculate the mass of the actual object once built
- Facility to calculate the cost of producing the article
- Simulation of designs without the need to build a prototype
- Import and export to allow the exchange of data with other software packages

CAM(Computer-Aided Manufacturing)

This is automated manufacturing process where computers are used to regulate (control) and monitor the production process in industries.

CAM uses some industrial robots or computer-controlled sensors for detecting:

- Excessive heat
- Faults
- Acceleration forces

CAM works well with CAD systems. Machinery is programmed automatically

A real CAD/CAM system enables any engineering component to be designed and manufactured using numerically controlled machine tools. The computer make some calculations for defining the tool path and generates the instructions necessary to produce the part. A machine tool such as a lathe is controlled by a computer which sends it instructions to select tools and to use them to make metal components.

CAM and CAD system systems are integrated. Data from CAD system is converted to a set of instructions for the processor controlling the CAM equipment. Once a part has been designed using the CAD software, the other processes are automatic. The following are involved:

(a) Conversion of data into a set of machine tool instructions;
(b) Operation of the CAM system:
   a. Selection of tools, e.g. cutter, drills, etc.
   b. Selection of speed e.g. for drills
   c. Movement of the tool to machine the part being manufactured.

Advantages of Computer Aided Design

- Saves a lot of time spent in drawing and testing objects.
- Saves costs of designing items
- Produces accurate scale diagrams.
- Images are easily manipulated on the screen.
- One can produce drawings in 3-dimensions as in buildings, gardens, bridges, etc.
- Images can be saved on the disk and retrieved at a later date.
- Drawings can be easily scaled up and down.
- It is easier to modify drawings
- A library of parts can be kept for future use
- Ability to do automatic costing of items
- Ability to model the design
- Can do ergonomic study.

NB: **Ergonomics**: the design and functionality of the computer environment and includes furniture setup and how it affect human beings, e.g. ventilation, security, space, noise, etc.

Disadvantages of Computer Aided Design
- Can lead to deskilling (skills which were highly valued are taken to be useless or of less value by the introduction of computers and workers degraded to less important jobs)
- Involves very high training costs to use the packages
- Can move work overseas
- Can lead to unemployment as one CAD operator can do work of 5 manual draftsmen.

Virtual Reality (VR)

It is an artificial 3-D environment created by a computer system. It is the creation of simulated multi-dimensional representation of real things, e.g. armies fighting against each other. Users wear data goggles, data gloves, etc. when interacting with the system.

Requirements for Virtual Reality (VR)
- **Data goggles/helmets** – these use display screens and optical systems that send 3-D images to the eyes.
- **Motion sensors**: measure the position and orientation of the head; this information is sent back to a computer which enables it to adjust the image being sent to the user.
- **Data gloves**, **suits containing sensors and joysticks** are all used to interface with a virtual reality system depending on the application.

NB. User wears data goggles, data helmet or data gloves to give a feeling of "being there". Apart from feeding sensory input to the user, these devices also monitor user actions e.g. data goggles track eye movement and respond by sending new video input.

Areas of use for Virtual Reality (VR)
1. **Entertainment**:
    a) Used in films/television as special effects where the studio audience wear VR helmets in a space simulation.
    b) Also used in computer arcade games like Need for Speed.
2. **Marketing**
    a) Used in virtual tours around houses and hotels, kitchen designs, ergonomics, etc.
3. **Training**: Areas of use include: military training, medical/dental training, teaching personnel how to use equipment and in general areas where training is dangerous and/or expensive e.g. flight simulators, car driving simulators, operating devices under water or in outer space, etc.
4. **Design**: Design of chemical and nuclear plants, ergonomic studies (e.g. factory layouts), helping to develop devices for handicapped people, etc.

How to create virtual reality images for use on a computer system
When a virtual tour of a house is shown on a website, the images need to be first created and then manipulated. The following summarises how this can be done (a similar method/technique could be used for various applications):
- take photos with, for example, a digital camera
- the photos are taken from a single point (reference point)
- the camera is rotated around the room as a number of photos are taken
- the images are "stitched" together using special imaging software
- photo images are re-sized and re-configured for Internet use
- Use hotspots on the web page to allow a user to move around the house (e.g. from room to room).
- Integrate plans and maps into the image to allow user to navigate the house.

NB: A <u>hotspot</u> is an area of a graphics object, or a section of text, that activates a function when selected. Hot spots are particularly common in multimedia applications, where selecting a hot spot can make the application display a picture, run a video, or open a new window, etc.

Features to see on a virtual tour website of a hotel being advertised on the internet
- hot spots on web page to allow user to move around the hotel
- plans and maps integrated to allow user to navigate the hotel
- ability to move from room to room to navigate whole hotel

Developments such as *broadband*, large computer memories and compression software have allowed virtual tours to be offered on the Internet and/or CD/DVD files.

Advantages of using virtual reality
- it is safer to use than testing real objects (if mistakes are made the results would be harmless; e.g. doing a medical task on a "virtual" patient is much safer in case of mistakes)
- Saves costs since there is no need of building the real thing e.g. testing out a real moon rocket or building a part of a chemical plant would be very expensive).
- It is possible to do tasks which would normally be impossible (e.g. walking inside a nuclear reactor, doing a task in outer space, etc.)
- There is a feeling of "being there" which makes the training more realistic
- Allow a number of very realistic scenarios to be tested out e.g. how to deal with an emergency on a chemical plant which could be made to be really realistic.

Robotics

- A **robot** is a reprogrammable, multifunctional computer controlled device designed to perform multiple tasks in industries, replacing human beings; e.g. for spray painting, welding, fixing parts of a car, etc.
- **Robotics** refers to the science of developing and the use of computer controlled devices to replace human beings in manufacturing.
- Robots can contain embedded processors or be linked to a computer system.
- They are pre-programmed to do a specific task or "taught" to remember instructions from a human operator carrying out the task manually e.g. teaching a robot to spray a car with paint.
- Robots rely on processors and sensors. The sensors gather information so that the robot knows it is the right time to do the task (e.g. is a car in position to be sprayed, is there an obstruction to prevent the robot doing its task, etc.)
- They are capable of doing some pseudo-intelligent tasks (e.g. different sized cars to be painted)
- Robots are mostly used (suitable) in the following areas:
  - **In very dangerous areas for human beings to work**, e.g. fire fighting, nuclear power stations, underground mining, chemical, nuclear factories, deep in the ocean, in space, etc.
  - **In areas where heavy items are to be lifted**, e.g. for loading containers in ships, in production lines, etc.
  - **In areas where the degree of accuracy is of utmost importance**, e.g. manufacturing of computer chips. Thus producing standardised goods.
  - **Where work is repeatedly executed and boring**, like traffic control at road junctions

Features (Parts) of a Robot

Robots have the following features (parts/characteristics):

- **Actuator (Manipulator)**: - A moving part which resembles a moving arm used for lifting and fitting items.
- **Transducer**: They convert analogue signals to voltage signals.
- **Sensors**: capture information and data from the environment in analogue form
- **Analogue-Digital Converter**(ADC):Convert analogues signals to digital signals
- **Microprocessor**: Processes data collected from sensors
- **Power supply**: - Usually electricity through compressors or stepper motors.
- **Controlling Computers**: - Connected through an interface to give instructions to the robot.
- Have some form of **interface (**connection points to power supply, human interface, etc.**)**

Robots can move from one position to another, e.g. when lifting cars into the warehouse and when going for recharging their batteries.

They **keep a record** of the distance they have travelled and the angles they have turned through so that they can return to original position

They can sense (using light sensor) and stop if unwanted object gets on their way.

They need information and programming for them to work. Information is provided by sensors.

Robots can be used for spray painting:
Problems that Robots may encounter when spray painting and the Solutions

- **Problem**: Robot may run out of paint
  Solution: include sensors in paint reservoir to indicate low paint levels
- **Problem:** something gets in path of robot
  Solution: include sensors to detect presence of an object blocking the robot
- **Problem:** Item may not be in the correct position
  Solution: include sensors to ensure item is in the correct position
- **Problem:** Item is not present
  Solution: Include sensors to detect if the item is present

Advantages of Using Robots

- Reduces labour costs as less people will be employed.
- High quality work is produced, which is also of high standard and consistent.
- Reduces cost (price) of goods due to reduced labour costs.
- Increases production volumes of goods since more goods are produced in a very short period of time.
- Ensures high degree of accuracy when producing goods.
- Robots can operate in the dark thereby saving electricity costs.
- Robots do not take breaks and holidays as they do not get tired.
- Robots can work 24 hours a day; they can work non-stop; they don't need a break
- Robots reduce accidents at traffic lights.
- Robots improve traffic flow.
- Robots can work in dangerous conditions.
- Create employment as the robots need to be serviced and installed.
- Eliminates human errors involved in the production process.
- Removes the need to do boring, very repetitive tasks leaving humans free to do the more skilled work such as quality control.

NB: However errors still exists due to:

- Loss of power to the robot.
- Fault in the software (wrongly programmed).

- Occurrences of hardware break down.
- Some robot components can be missing or misplaced.

Disadvantages of Using Robots
- Leads to unemployment as humans are replaced by robots
- Electricity expenses are very high.
- they can find it difficult to deal with "unusual" circumstances e.g. a door is missing from a car waiting on the paint spraying line
- leads to de-skilling since many tasks are taken over by robots

Artificial Intelligence
Artificial Intelligence (AI) is the science of developing computer systems that have the ability to learn from experience and mimic human reasoning in specific areas, as in medical diagnosis, mineral prospecting, etc. Expert systems are a branch of Artificial Intelligence.

Expert Systems

These are computer systems developed to mimic human reasoning and work at the level of an expert in a particular field, e.g. in medical diagnosis. Expert systems are used in the following fields:

oil or minerals prospecting, diagnosing a person's illness, Diagnostics (e.g. finding faults in a car engine, etc.), tax and financial calculations, complex "thinking" tasks such as *chess,* weather forecasting, criminology/forensic science, career choices, *etc*

Components (Elements) of an Expert System
- The diagram below shows some of the components:
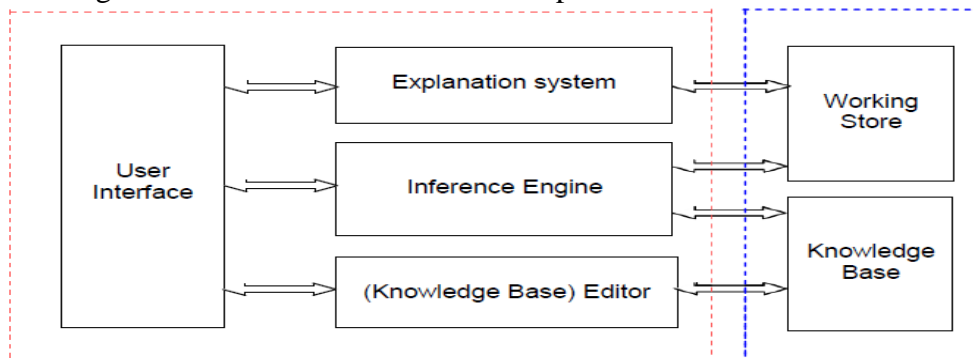
- **Knowledge Base**: a representation of facts (data) in a particular field (e.g. diseases, symptoms, treatments, etc. as in medical diagnosis)
- **Inference procedure (engine)**: contains reasoning methods used to arrive at a conclusion using information in the knowledge base. It contains interrogation technique/questions and answers.
- **User interfaces**: these enable people to form queries, provide information, and interact with the system.
- **Explanation facilities (system)**: enable the systems to explain or justify their conclusions, and they also enable developers to check on the operation of the system themselves.
- **Rule Base**: This is found in the **Working Store**. It contains inference rules and the inference engine uses these to draw its conclusions.

The system uses a rule base and an inference engine together to simulate human reasoning when analysing a problem and arriving at a conclusion. To simulate human processes it is necessary to have a vast amount of information stored in the knowledge base and the reasoning set out as a set of rules in the rule base.

Steps Followed When Producing/Creating an Expert System
- Gather information from experts in the field(e.g doctors, geologists, etc).
- Design the knowledge base.
- Input data into knowledge base.
- Design the rule base.
- Design inference engine
- Design display of results
- Test system with known problems and solutions
- Design appropriate user interface

Ways of Improving Expert Systems
- Frequently carrying out researches and making updates.
- Quickly inputting new data into the knowledge base.
- Assigning its control to a number of highly experienced personnel who will monitor and make updates as soon as possible.

Advantages of Expert Systems
- Provides consistent answers
- Fast identification of solutions to problems by quickly analysing data.
- They produce reliable and accurate results if well programed.
- There is no need for an expert to be present since they can act as a prompt to an expert.
- They can deal with complex situations much faster than humans.
- They could be used in hazardous areas (e.g. Oil prospecting).
- They do not forget as humans do.
- Many copies can be made at a low cost.
- Knowledge of several experts is combined.
- Save costs on wages and salaries for staff.
- Conclusions are based on logic, no emotions involved.
- Can explain its reasoning method

Disadvantages of Expert Systems
- They lack creativity/does not reason.
- They are unable to learn outside the system.
- They lack sensory experience.
- They take time and are difficult to develop.
- They need to be constantly updated to keep pace with recent developments in the field they are applied.
- This may be difficult and time consuming to use.
- Data is entered by humans who may make mistakes in doing so. This can lead to incorrect decisions being made
- lacks common sense in some of the decision making processes
- cannot adapt to changing environments unless the knowledge base is continually updated
- errors in knowledge base can lead to incorrect decisions.
- expensive system to develop and set up in the first place
- needs considerable training to ensure system used correctly by operators
- leads to deskilling and unemployment.
- They are usually dedicated to one domain area (for just one task)

Mineral and Oil Prospecting (Using expert systems)

An Expert System called prospector asks the user to enter geological formations of a particular area such as rock and soil type and then gives advice on the possible mineral deposits that can be found in that area. An interactive user screen appears. Questions are asked about geological profiles. Answers to questions are typed in. The inference engine searches the knowledge base using the rule base.

Inputs

Geological data such as rock and soil type

Processing

Draws conclusions from rules and facts using geological data entered and the mineral data stored in the knowledge base. E.g

- suggest the probability of finding oil as an output
- indicates the probable depth of deposits
- predicts geological deposits above the soil
- produces contour maps showing concentration of minerals, rocks, etc

Output

- Possible mineral deposits that can be found in that area
- Geological maps

Data Logging

The automatic collection of data from source at set intervals, over a period of time, for use at a later stage, using sensors. A device that automatically collects data from source at set intervals for use at a later stage is called a **data logger**.

Features of Data Loggers:

- They contain processor inside them.
- **Have Interface**: Devices that act as connection point between data loggers and the computer.
- **They have own storage facility**: For storage of data collected from sensors
- They contain or are connected to **sensors** that are used for collecting data in analogue form. All physical properties can be measured with sensors e.g. light, heat, sound, pressure, acidity and humidity.

Sensor type	Purpose
Mercury Tilt switch	Detects if device is tilted, e.g. a vending machine
Light sensor	Detects the intensity of light (light level), e.g. so as to turn on or off street lights. Used also in greenhouses, automatic door, traffic control, etc Can detect light reflected from a barcode
Push switch	Used to turn on or off interior light, e.g inside a fridge if a door is opened or closed
Temperature sensor	Detects temperature levels in central heating systems, chemical plants, etc.
Infra-red sensor	Used in burglar alarms, counting people, detecting heat sources
Sound sensor	Records sound levels from beer halls, houses, etc
Proximity sensor	Detects how close to each other are two parts, e.g. if a window is opened; an alarm is raised because the proximity between the window and the sensor is changed.
Position sensor	Senses the angle of an object from a certain point, e.g. from a robot
Pressure/motion sensor	senses when someone has walked over an object e.g. used in burglar alarm systems, automatic doors, counting vehicles, etc
Acoustic sensor	Listening to foot steps (in burglar alarms), sound from broken glass, etc
pH sensor	Measures the acidity or alkalinity of objects e.g. of soil and water, in pollution monitoring, chemical process control, etc
Humidity(moisture) sensor	Measures humidity (moisture) levels in air, greenhouses, irrigation systems, etc

Distance sensor (could be proximity)	Measure the distance from one point to another
Oxygen sensor	Used to monitor pollution levels

- They can be connected to small keyboards or other special reading devices.
- They are connected to an Analogue to Digital Converter (ADC), which converts data signals in continuously varying form (analogue) collected by sensors into discrete (digital) values that can be accepted by the computer.

Types of Data Loggers
### a. Data loggers with permanent computer connection
- These take readings and send them to the computer in offices through connection cables or through wireless connections.
- The time intervals (time between each reading) and the period over which the logging takes place can vary
- The computer may process the readings instantly and produce graphs
- The readings may also be stored on the disk for processing at a later date
- These are suitable for experiments in laboratories

b. Data loggers with temporary connections to the computer
- These are not always connected to the computer, but are connected when necessary
- They are mostly used in monitoring environmental conditions over a period of time
- The time intervals (time between each reading) and the period over which the logging takes place can vary. The **time interval** for data logging is the time between readings. The **logging period** is the total length of time over which readings are taken.
- Reading are stored by the data logger and loaded into the computer at a later date for processing
- They can be used in remote areas (not directly connected to the computer): **remote data logging**.

Performing the data logging process
This can be illustrated by the diagram below:

Boiling water   Interface box   Computer
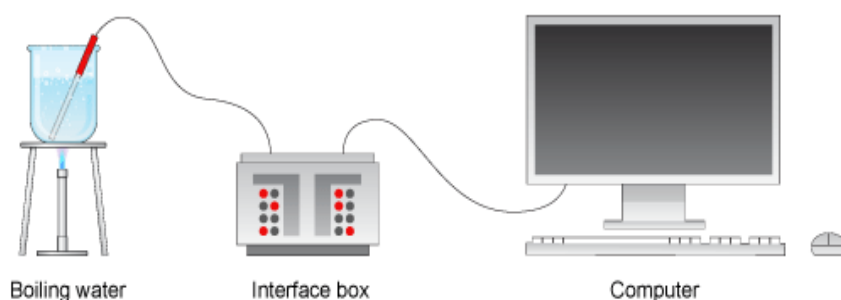
- Connect sensor to the interface box
- Connect interface to the computer
- Load data logging software (if not loaded already)
- Enter time interval (e.g. 30 seconds)
- Specify total reading time
- Display results as a list on the screen
- Produce graphs for analysis of data. Other graphs can be plotted automatically
- Save data on disk for use at a later date
- Export data to other applications like spreadsheet

Benefits of computerised data logging.
- Data loggers are a very fast method of data collection than manual methods.

- Data can be processed immediately (real-time)
- Data loggers are very accurate than humans in collecting data.
- Data loggers enable collection of data on events that happen too quickly than human beings could do.
- They can also record data on events that happen too slowly and boring for human beings to carry
- Data loggers stored data for a very long period of time.
- Data loggers can work 24 hours a day, thus ensuring continuous data logging process.

Monitoring and Control Systems

Monitoring System:

A computer program that keeps track and verifies the operations of a data-processing system and warn the user if an anomaly occurs, e.g. patient monitoring in hospital, monitoring key parameters in chemical and nuclear plants, monitoring for intruders in houses using burglar alarms, etc. In monitoring, there is human intervention. In a monitoring system:

- computer system takes information from the sensors
- data from sensors is converted to digital form using the ADC
- processor compares the data from sensors with stored values (parameters)
- system informs the user of status either by read outs
- if values are within acceptable parameters, nothing is done and monitoring continues
- if values are outside acceptable parameters, the system warns or alarms if values are outside set parameters.
- can update files but no changes to the process are done during monitoring

Examples of monitoring systems include: Patient monitoring in hospitals, Monitoring scientific experiments in laboratories, A burglar alarm system, Environmental monitoring (oxygen or pollution level in river)

Monitoring Oxygen Levels in a River (Environmental Monitoring)
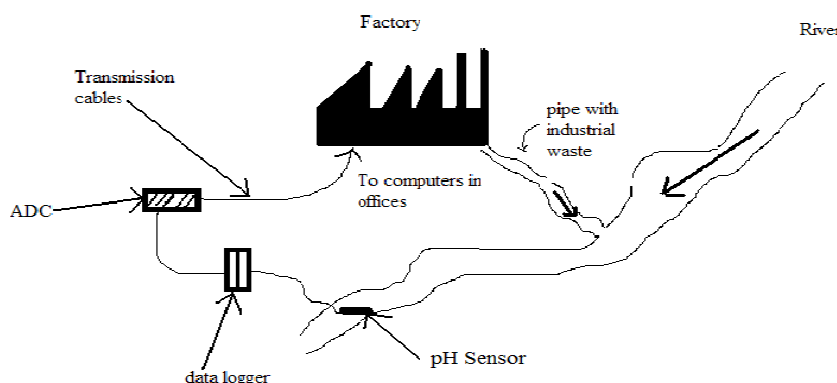
- Sensors read data from the river (Oxygen level, acidity level, using the pH sensor)
- Data from sensors is converted to digital form
- Computer stores received data
- Oxygen and acidity levels from sensors are compared with historically stored (pre-set values/parameters)
- Either data can be transferred to CD/DVD/Memory stick for later analysis OR

- Data is send to the monitoring station directly through mobile phone network or through cables.
- Red colour is displayed on screen if values are outside acceptable level or an alarm is sound.

Monitoring of Patient's Vital Signs in Hospital

- Sensors read key vital signs (e.g. pulse/heart rate, temperature, blood pressure, respiration, blood sugar level, blood gases, Brain activity, etc.)
- The data from sensors is converted to digital form using ADC
- The data is stored in computer memory
- The computer compares data from sensors with pre-set parameters
- The results are output on the screen in form of graphs, actual values humans can read, colour display on screen (Red in case of danger, green of ok, etc), alarm/sound if there is danger.
- An alarm is activated if any of the data is outside acceptable parameters
- The system continues to monitor the patient until the computer is tuned off.

These systems are designed to monitor critically ill patients or premature babies. Some biosensors connected to the computer are attached to the patient for tracking and recording vital signs such as heart beat, blood pressure and brain activity. The biosensors will transmit readings to the central computer should the situation go beyond a critical warning level and:

- issue a warning on the computer display for nurses on standby
- sound a warning siren, alarm, beep or sound to alert medical staff
- flash a light to draw attention of medical staff

Patients in intensive care are monitored through sensors. The sensors measure and give feedback pertaining to: blood pressure, temperature level, weight, pulse rate, etc.
The computer is pre-set with normal range of values. It compares these with feedback from sensors.
Computers record patients' medical data over some time for later analysis. Data recorded includes:

- **Taking** measurements on patients, for instance: blood pressure, temperature level, weight, pulse rate etc. This relieves nurses of some duties that will be boring, making them faster and more reliable.
- There are however some hospital tasks that are more suitable for human beings to perform than computers. These include dressing patients, bathing patients, etc.

In hospitals, computers also perform the following:

- Used to **hold data** for children's immunisation processes.
- **Monitoring** of patients during surgery as they control body scanners and sensors.
- **For Stock control :** For hospital blood stocks, food stocks, drug stocks, etc
- **For patient Booking system :** For out-patients and in-patients to see the doctor
- **For keeping Personnel records :** For keeping and management of employee records

Surveillance Systems for House Breakers

The interaction between sensors and microprocessor in a surveillance system is as follows:

- sensors around the house would gather information
- e.g. has a light beam been broken
- has pressure pad detected excess pressure
- has infra-red beam detected excess heat
- has acoustic sensor detected any noise such as breaking glass

- data translated into digital using an ADC (analogue to digital converter)
- microprocessor/computer will compare signal from sensor with stored information
- e.g. signal that light beam is broken
  > pressure > stored "normal" value
  > heat level > stored "normal" value
  > acoustic level > "stored" normal value
- if any values are outside normal range, microprocessor/computer sends a signal to an alarm and/or flashing light
- system also automatically sends signal to police/security company
- since the house is large, sensors will be in zones; therefore computer will indicate on a control panel the zone where intruder broke in

Control System

- It is a system in which one or more computers are used to monitor and regulate the operations of non-computer equipment e.g. in oil refineries.
- Control systems involve monitoring and logging of physical quantities, provide an analysis of performance and allows some user interaction.
- Feedback is an essential element as well as timing.
- Most control systems are real-time systems, e.g. in oil refining, chemical processing, traffic lights (controlling the sequence of lights to maintain optimum traffic flow), chemical and nuclear plants (opening and closing valves, safety systems, etc.), etc.
- In computer control:
  - ✓ computer system takes information from the sensors
  - ✓ compares the data with stored values
  - ✓ Takes action to try to get values within acceptable ranges by sending signals to devices to open/close, on/off etc. Devices that receive signals include valves, motors, windows, tapes, etc.
  - ✓ output from system can affect next input (feedback)

Examples of control systems include: controlling a nuclear reactor, controlling a chemical process, controlling a greenhouse environment, controlling central heating system, controlling a set of traffic lights

Components of Computer Control

- A **computer** (or microprocessor).
- **Sensors** to enable the computer to detect quantities such as temperature or pressure.
- **Motor**: Devices which actually turns on or off other devices, e.g power supply, windows, vents, water pipes
- **Devices** for the computer to turn on and off.
- An **interface** to connect the sensors and devices to the computer.
- **software** to read data from the sensors and turn the devices on and off

How control is done

- Sensors gather information from the environment in analogue form.
- The ADC translates the analogue data into digital form
- The microprocessor compares the incoming data with the data values already stored in memory.
- If values are outside set parameters, the computer sends a signal to a device to switch on or off (e.g. if controlling a central heating system, if temperature > set temperature a heater will be switched off and/or a cooling fan switched on; if the

temperature is below the set point then the heating will be switched on and/or a cooling fan switched off).
- The digital signal will be converted to analogue form using a DAC (Digital to Analogue Converter). Actuators are usually employed to operate devices like valves, heaters, etc.
- The computer/microprocessor system will continually monitor the data coming from the sensors

NB: In chemical and nuclear plants, there is often a combination of monitoring **and** control taking place. Information from sensors is often displayed on a control panel where operators can see key values and alarm conditions (e.g. if a system monitors temperatures and 110^0C is the normal temperature and 120^0C is the alarm temperature, the control panel will show normal, present and alarm values in the form of read outs – **either** the computer will automatically take action if necessary or the operator will take action (override the system if necessary)

Chemical Process Control

Consider the following situation:
A chemical process only works if temperature is above 70^oC and less than 100^oC, and the pH (acidity) level is between 3.5 and 8.5. The heater is used to warm the reactor and valves are used to add acid when necessary to maintain the acidity. The following is a description of how the sensors and the computer in this system works:
- **Temperature** and **chemical sensors** read data from the chemical process
- Data from these sensors is **converted to digital form** using ADC
- Computer compares values from sensors with pre-set data in computer memory
  - If temperature is too low, a signal is send to switch on heaters
  - If temperature is too high, a signal is send to switch off heaters
  - If temperature is within acceptable range, no action is taken
  - If pH is too high, signal is send to open valve and acid is added
  - If pH is too low, signal is send to close valve
  - If pH is within acceptable levels, no action is taken
  - Signals are changed from digital to analogue so as to control heaters and valves
- This continues as long as the computer is activated.

Control in Greenhouses

- The environment must be kept constant if plants are to grow successfully in greenhouses.
- Temperature and humidity in the air needs to be controlled so that it is kept constant
- Sensors are used to record humidity and temperature levels in analogue form. The analogue signals are sent to the computer
- The computer will have stored **(pre-set)** values of minimum acceptable level and maximum acceptable level for both temperature and humidity
- If the sensor records humidity level below the minimum acceptable level, the computer will send signal to the actuator to close the windows and switch on the pump for a certain period of time, which will spray water as a fine mist inside the greenhouse.
- Too much humidity will cause the processor to send signals to the actuator to open windows to assist ventilation and drying out air.
- In case of temperature, if the greenhouse becomes too hot, the windows are opened and heater turned off. If it becomes too cold, windows are closed and heater switched on.

Inputs:
- Humidity/moisture (collected from humidity/moisture sensor),
- Temperature (all in analogue form; collected from temperature sensor)

Processing:
- detecting temperature/humidity level
- Processors compares pre-set values in the computer with data collected from sensors
- Processor instructs actuator to take action if values exceed or are less than minimum/maximum pre-set values

Outputs:
- Windows open or closed (digital form)
- Heater on or off (digital)
- Pump for water supply on or off (digital)

Computerised Traffic Control System

Input:
- Data is read from sensors(light sensor, motion/pressure sensor, weight sensor, sound sensor, etc)
- Data is read from camera images

Processing:
- Computers analyse data from sensors.
- Computers calculate average traffic flow and speed.
- Computer sends signals to actuators to adjust change of lights and timing

Output:
- Change of lights at junction.
- change timing plan

Advantages of using computerised traffic control systems
- Ensures improved traffic flow control.
- Reduces traffic accidents.
- Keeps delays to a minimum.
- Reduces pollution. cars use less fuel

In case of an emergency, the computerised traffic system may perform any one of the following:
- Give uninterrupted path through the system of linked traffic lights.
- Give green link – wave for all traffic to pass.
- Turn all lights to red.
- Activate emergency generator.
- Sound an alarm.

Microprocessor-Controlled Streetlights

Input:
- Pre-set values of Sunset time and Sunrise time
- Light level (Light sensor sends measurement of light to microprocessor, ADC converts this to   digital)

Processing:
- Processor compares sunrise time, sunset time and current time.
- If sunrise time = current time or higher, the processor send signal to actuator so that it switches off lights, else,
- if signal equals sun set time, the processor send signal to actuator so that it switches on light.

- Also the amount of light is compared with pre-set value. If higher – nothing happens, If lower or equal sends signal to send signal to actuator so that it switches on the streetlights.

Output:
Lights switched on or off

Benefits of Monitoring and Control Systems

- It is safer to use computer control than human beings, e.g. in monitoring temperature in a blast furnace, monitoring radiation level in a nuclear reactor, etc.
- It is faster to respond to problems that may affect the system, e.g. nuclear reactor can automatically shut down in response to earthquake
- They don't get tired, thus computers can work 24/7
- Computer systems do not miss key data that must be entered into the system as humans do.
- Computer control is more reliable than human beings as computer does not forget to take readings
- computers are more accurate and can take more frequent readings (e.g. if readings need to be taken every 30 seconds, humans can make mistakes or miss readings or even find it impossible to take readings at such short time intervals)
- data can be automatically displayed and analysed without the need to enter data manually (which in itself could introduce errors into the system)
- Data can be automatically stored and used in other programs.
- The results of the system can be automatically stored in a spread-sheet package or a database package for future reference.
- Computer's response time is faster, which is important especially in patient monitoring

Disadvantages of Monitoring and Control Systems
- High initial costs because computer-controlled devices are more expensive to buy and to set up.
- Fewer workers will be employed leading to a rise in the numbers of the unemployed.
- The software for the control system is very expensive
- If the computer malfunctions the system will not work
- If there is a power cut the system will not work
- The computer can't react to unexpected events like a human could. It can only respond in the way it has been programmed to.
- It can cause some concern if total control for a system and the decisions are handed over to a computer.

Automated Systems
- These are control systems that are dedicated to one particular task and lack the ability to collect and analyse data as in digital cameras.
- They do not allow for or act on user interaction, e.g. washing machines, cameras, watches.
- Most control systems have embedded computers systems inside them.

NB: Embedded Computers: –
- Refers to use of microprocessors in non-computer equipment like in cameras, washing machines, watches, etc. They do not have mouse, monitor and keyboards.
- These are normally dedicated for a specific task they are designed for. Embedded computers are also found in household items like camera, microwave, washing machine,

video recorder, fridge, sewing machine, air conditioning, electronic toys, rice cooker dish washer, Televisions, alarms, clock, radio, DVD players, etc.

Refrigerators

Inputs:
- temperature level (from temperature sensor/ or entered manually through the number pad),
- Pressure (from pressure sensor/contact switch/push switch) ,
- push switch setting

Processing:
- Analogue data from sensors is converted to digital by the ADC
- Processor controls temperature level by comparing with pre-set values.
- If temperature is higher than pre-set value, the processor sends signal to motor to switch on compressor
- If not higher, the compressor is switched off by the actuator
- Processor controls the display panel.
- Processor sends signals to display panel and to the motor to switch lights on or off.

Outputs
- Switch on lights if door is opened and off when closed
- Light emitting diodes indicating current temperature of the inside of refrigerator.
- A warning buzzer (sound) if light is left open.
- Cold temperature

Air Conditioners

Inputs:
- Pre-set temperature level
- Temperature from temperature sensors
- Pressure from pressure sensors: monitors pressure of refrigerant

Processing
- Processor controls temperature.
- Processor sends signal to motor to change fan speed
- If temperature is below pre-set value, the processor gives motor signal so that it switches off fans
- If temperature is above pre-set value, the processor gives motor signal so that it switches on fans
- Processor controls timing and the display panel

Output
- Cool temperatures in the room
- Fans switched off or on depending on the situation

Digital Camera:

Input:
- Light mode(night or day mode)
- Film speed
- Colour setting

Processing:
- Processor sends signal to automatically adjust film speed,
- Processor positions the end of film,
- Processor sends signal to adjust distance from object,
- Processor sends signal to adjusts light.

- Processor sends signal to save image on the memory card

Output
- Sound to indicate that the film/picture has been taken
- Image/film captured and stored
- Light flashed to indicate film/picture is taken

Speed Cameras

These are used on roads to take photographs of cars which have exceeded the speed limit. Some of these cameras use microprocessor controlled chips to store information.

The advantages of speed cameras with microprocessor controlled chips are that:
- Data and images can be transferred automatically which will be faster.
- Image can be viewed straight away.
- Can store considerably more data and photos.
- Can store other information (apart from photo image) e.g. road conditions.
- Chips can be re-used.

Inputs
- Maximum speed (speed limits)
- Road condition

Processing:

Tasks which would be carried out by the microprocessor as a speeding car approaches a camera include:
- Sense and record speed of vehicle.
- Compare speed of vehicle with stored value(s) and decide whether photograph should be taken.
- Check on value of light intensity.
- Adjust focal length, focus image, adjust shutter speed and set exposure.

Tasks which would be carried out by the microprocessor as the photograph is being taken include:
- Log the time
- Log the date.
- Log the speed.
- Record the road conditions.
- Operate ―flash.
- Operate shutter.
- Instructs storage of the image.
- Check on value of light intensity.
- Adjust focal length and focus image.

Outputs
- Video/pictures of cars captured
- Alarms of over-speeding cars

Microwave Cookers

Function by switching a microwave unit **on** for a sufficient time to either defreeze frozen food or cook it. It is used to cook food quickly by using waves (similar to radio waves) to heat the food.

Inputs:

Modern cookers have sensors attached to a microprocessor for detecting as inputs:
> Weight of food
> Temperature of food

Some cookers will also have additional sensors for detecting:
- Amount of steam produced during cooking

- Amount of alcohol produced

Processing:
- The microprocessor continually monitors sensor readings and by referring to a programmed in-built database of food types.
- The microprocessor determines **time** needed to cook or defreeze food.
- IF a temperature in the food indicates the food is cooked OR the time set on the oven clock is reached THEN microwaves are not produced

Output: Heat for cooking, Light indicating that food is cooked, power turned off if food is cooked.

***NB**:-Tasks performed **by microprocessor** inside some of the devices include:
- **In digital camera**: automatically adjust film speed, positions the end of film, adjust distance from object, adjusts light.
- **In washing machine**: Controls the amount of water. Adjust and controls speed of wash. Control temperature of water and the time taken to wash the clothes.
- **In fridges**: Controls temperature level. Control the display panel. Switch on lights if door is opened and off when closed.
- **In air conditioners**: Controls temperature. Controls timing and the display panel

Differences between Control and Automated systems

Control Systems	Automated Systems
Can have several tasks	Dedicated to one task
Can collect and analyse data	lack the ability to collect and analyse data
Allows user intervention	They do not allow for or act on user intervention
Has an element of feedback	Do not involve feedback

Feedback: The process in which output of a system can affect its own output. It is whereby part of the output of a system is returned to its input in order to regulate its further output.

Simulation and Modelling

Modelling

A model is a representation of a real-life process/object which consists of a set of equations which describes its behavior.
Modeling is the creation of a programmed simulation of a situation/process in order to predict future trends.
It involves the use of **mathematical formulas** and calculations to predict what is likely to happen based on data recorded.
In modeling, we use the computer to solve equations so that we can carry out simulation.
An equation for part of an economic model could be:

>*Unemployment = people able to work – people working.*

You can develop and evaluate your own models or use the models that have already been set up to simulate a real life situations. 3-D Models can be built using CAD, e.g. for planning stores.

Advantages of modeling
- No equipment is damaged
- People are not put in any danger
- Expensive prototypes don't need to be built
- Time can be sped up or slowed down
- Models can be run and re-run over and over
- Modifications can easily be made and re-tested quickly

Disadvantages of Modeling

- The results depend on how good the model is and how much data was used to create it in the first place.
- Models and simulations can't ever completely re-create real-life situations.
- Not every possible situation may have been included in the model.
- The equipment and software are expensive to purchase.
- Staff need to be trained how to use the software and equipment.

Simulation

Simulation is the study of the behaviour of a system using models in order to predict future real life events, like population growth, flight simulator, etc. It involves feeding values into a model to see how the model behaves.

In simulation, past and present data, as well as models are analysed in order to predict the future. Simulation is used in the following areas:

Training (e.g. pilots, drivers, medical doctors, etc.), running/testing chemical plants and nuclear plants, trying out equipment to be used under sea or in outer space, crash testing cars, financial simulations (e.g. stock market predictions based on various scenarios), population growth (i.e. predict how the world's population will increase based on a number of different scenarios), queues (e.g. simulating queues at supermarket checkouts), weather forecasting

Advantages of simulation

- saves cost (rather than doing the real thing)
- safer (scenarios tried out on the simulation first before used in reality)
- possible to try out various scenarios in advance
- Some environments make simulations the only way to carry out a task beforehand (e.g. outer space, under sea, chemical processes, nuclear reactors, etc.)
- faster (no need to build and test real system, so it is possible to get results more quickly)

Flight Simulator

- Flight simulators are used to train pilots how to fly aircraft.
- They can also be used to test new aircraft before they are actually flown for the first time.
- Flight simulators are expensive to buy but are much cheaper than actual aircraft.

A landing simulation with ice on the runway, thick fog and only one of the four engines working would really test the pilot's ability

Flight simulators enable pilots to experience turbulence, snowstorms, thunderstorms, fog, etc, without leaving the ground.

Simulation At Road Junction

The following is a series of traffic lights at two busy junctions:

In this simulation it is necessary to consider
- In this simulation it is necessary to consider:
- how and what data is gathered
- how the simulation is done
- how the system would work in real life
- why simulations are done

How data is gathered

To make this as realistic as possible, data needs to be gathered over a long period of time. This can be done by sensors in/near the road, using cameras or manual data collection. Data gathered includes:
- number of vehicles passing in all directions at each junction
- number of vehicles passing in all directions at each junction at a particular time of the day
- Number of cars build up at a junction before lights change
- is it a week day or weekend or public holiday
- how long it takes to clear vehicles at a junction
- other data (e.g. pedestrian crossings)
- time taken for largest/slowest vehicle to pass through a junction
- other factors (e.g. filtering of traffic to the right or left)

How simulation is done

The data is entered into the computer and the simulation is run. The following scenarios may be tried out:
- timing of lights is varied to see how the traffic flow is affected
- build up number of vehicles stopped at a junction and change timing of lights to see how it affects the traffic flow
- increase/decrease traffic flow in all directions to see how the traffic is affected
- try out the impact of accidents
- consider passage of emergency vehicles
- effect of adding in pedestrian crossings
- once the simulation is run, the timing of the lights is determined and how they interact so that the maximum traffic flow is achieved;
- fault scenarios (e.g. an accident) and their impact are considered

How the system works in real time
- Sensors in/near the road gather data (these can be light/infra-red sensors, induction loops, pressure sensors, etc.)
- the data is usually number of vehicles passing a particular point
- the data is sent to a control box or computer system
- the gathered data is compared to data stored in the system (the stored data is based on simulation runs, how the number of vehicles at a junction at a particular time of day affects the traffic flow, etc.)
- the control box or computer "decides" what course of action to take and sends signals to the traffic lights to change timing if necessary
- as with any system involving sensors, ADC and DAC interfaces may be needed

Simulation in Weather Forecasting

Another example of simulation is predicting weather (i.e. a weather forecaster).

How and what data is collected
- Super computers are used since they control satellites in orbit.
- sensors measure the following variables in analogue form
  - pressure, temperature, relative humidity, wind speed and wind direction

- sensors are placed in weather balloons and/or weather stations
- information is also got from satellites
- pilots also send in information regarding weather conditions during long flights
- The data collected by the data loggers will be in analogue form and the ADC device converts this to discrete values (digital) for the computer to accept.

How the simulation is done

- Data and information from the sensors/satellites is sent to computer for processing
- This data is compared to information stored on files which contain known weather patterns from the past
- predictions are made based on these comparisons
- Calculations are made to produce expected minimum and maximum temperatures, pressure, moisture content, rainfall patterns, etc
- The computer produces weather maps showing isobars, temperatures, etc.
- computer can show graphically how weather (e.g. cloud formations) will change with time (i.e. predict weather patterns) – this is often presented as a computer generated video showing how clouds build up, how temperature and pressure changes over, for example, the next 7 days, wind speeds etc.
- It is also possible to do statistical analysis and predict the percentage probability that certain weather conditions will occur.

How future environment/climate changes can be predicted

- Weather forecasting uses the concept of simulation and modelling i.e. predicting the weather by studying a mathematical weather model.
- The measurements are then entered into a mathematical weather model which then makes complex calculations to come up with the weather reports.
- based on changes in weather patterns, the processor carries out a statistical prediction
- model is able to change parameters to see how future climate can be affected
- there is need to review a lot of previous data over a number of years to check if changes are genuine, for example 20 years, predictions compared to actual climate conditions to validate/further refine the model
- can make use of spread sheets and statistical software packages for other calculations

Output:

- Information obtained is displayed on the computer screen ready for presentation on televisions
- Information can be printed documents.
- Tables and graphs are produced
- Rainfall maps and isobars are produced.
- Expected minimum and maximum temperatures are produced
- Areas of pressure change with time so it is possible to predict rainfall, strong winds, etc. in advance
- Show how the clouds patterns will change with time so it is possible to predict rainfall

Advantages of this automatic weather forecasting system include:

- Computer can take readings during weekends and public holidays without the presence of human beings.
- Computer readings are more accurate.
- Readings can be taken more frequently.
- Readings can be taken any time of day or night.
- Graphs can be produced more easily.
- Readings can be taken more reliably.
- Humans can be more productive if not collecting data.

Simulating Queuing in a Supermarket

Collecting data for the model:
- Sensors count **number** of people at checkouts points at each **time of day** and each **day of the week**
- count how many people build up at the checkouts on either is it a **weekday**, **weekend** or **bank holiday**
- determine how long it take to serve a customer

Carrying out the simulation
- number of checkouts opened and see how flow of people affected
- Build up number of customers at checkout, open extra checkouts and see how it affects time to be served, etc.
- Increase/decrease number of customers and observe the affect
- Once simulation is run, number of checkouts needed is determined and interaction with customers is determined so that optimum throughput is achieved
- Look at fault scenarios (breakdown of equipment etc.)

Embedded Web Technology (EWT)

- This is a new technology that uses the Internet in real time to control/interact with a device which contains an embedded microprocessor.
- The user needs to be authorised to do this and can control a device anywhere using a web browser (e.g. from a computer or even a mobile phone which is web-enabled).
- Example: An oven contains an embedded processor. The owner can use a web ready mobile phone anywhere to control the oven remotely.
- By accessing a web site one is able to send instructions to control the oven.
- It is possible to control any device in this way if it contains an embedded processor e.g. television, DVD player/recorder, washing machine, scientific experiments in remote areas such as outer space

Global Positioning Satellites (GPS)

GPS - A navigational system involving satellites and computers that can determine the latitude and longitude (position) of a receiver on earth by computing the time difference for signals from different satellites to reach the receiver.
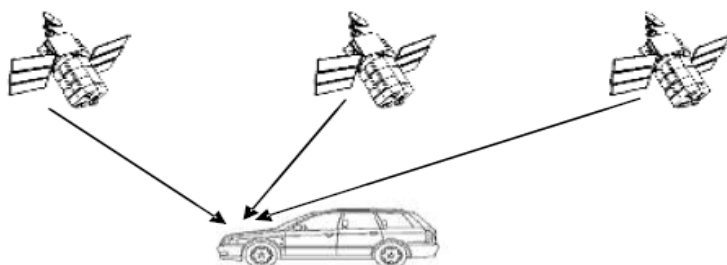
- GPS systems are used to determine the exact location of a car, airplane, ship or any form of transport which travels from one place to another.
- In vehicles these systems are called Satellite Navigation Systems (sat nav).
- Satellites in outer space transmit signals to the Earth.
- Computers in vehicles (e.g. car, airplane or ship) receive and interpret these signals.

- Positioning depends on very accurate timing – atomic clocks are used because of their accuracy to within a fraction of a second per day.
- Each satellite transmits data indicating its position and time.
- The computer in the vehicle calculates its location based on the information from at least three satellites as shown below:
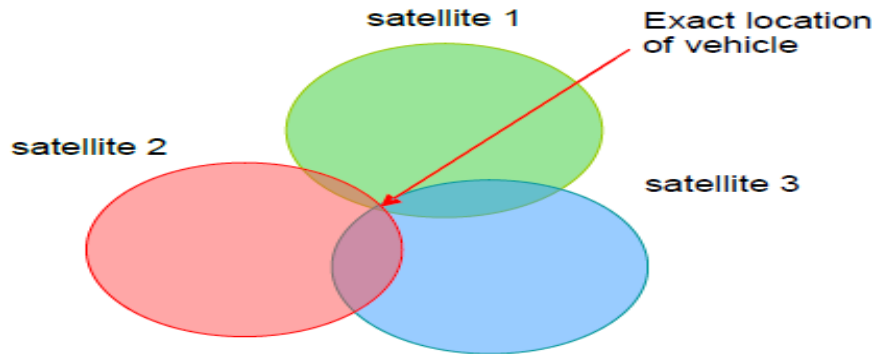
- In motor vehicles the system is called satellite navigation (sat nav).
- The on board computer contains pre-stored road maps.
- The vehicle's exact location, based on satellite positioning, can be shown on the map; the driver can then be given verbal directions e.g. *"turn left into Josiah Tongogara Road"* **OR** a screen output showing the vehicle moving on the map

How satellite navigation systems can be used to calculate a vehicle's position
- satellites in outer space transmit signals to the Earth
- computers in the bus receive and interpret these signals
- the satellite relies on very accurate timing (atomic clocks)
- each satellite transmits data indicating position and time
- computer in bus calculates its position based on received satellite data
- at least three satellites are used to give the vehicle's exact position

How the drivers uses the satellite navigation system:
- the computer has a number of pre-stored maps
- bus location shown on appropriate map
- directions are given verbally or on-screen output (on a map)

Advantages
- It is far safer since a driver of a vehicle doesn't have to consult maps whilst driving.
- it also removes error (e.g. going the wrong way down a one-way street).
- Sat nav systems can also give additional information such as position of speed cameras, estimate time of arrival, etc.
- GPS can monitor a vehicle's position if it has broken down or has been stolen (vehicle tracking system).
- In airplanes GPS can pinpoint its exact location in case of an accident which enables search teams to quickly respond to the incident.

Disadvantages
- maps may not up to date therefore instructed to turn into a road which no longer exists
- road closures due to accidents or road works may cause problems to a sat nav system
- signal loss can cause problems with GPS systems
- potential interferences from external sources (major problem on aircraft)
- incorrect start and end point entered into system can cause problems

THE INTERNET

Internet stands for INTERnational NETwork and it is a global (world-wide) connection of computer networks for information sharing. On the internet, one is able to access data stored on a server in any part of the world as long as it is connected to the internet itself. The internet can be accessed from anywhere. It is also available to anyone. No one controls the internet as computers in different countries are connected yet the countries have different laws. However, each country may regulate internet usage in its own territory.

Definition of Terms

Information Superhighway (ISH): A global network of computers for moving huge amounts of information via satellite and cable connection. Information found on ISH includes home shopping, entertainment, news, software downloads and help, online banking, stock market dealing, jobs, (vacancies), university placements, etc.

Information Technology (IT): - The use of computers in information handling and communication.

Information Age: A period beginning in the last quarter of the 20th century when information became easily accessible through publications and through the manipulation of information by computers and computer networks.

Global Village: the use of the internet to access information from any part of the world.

Information and Communication Technology (ICT): The use of computers and related method as a tool for information communication, for instance through e-mails, cell phones, etc.

Web page: an HTML document or page on the internet that contains information about an organisation.

Website:-a collection of HTML documents at the same domain, often with a common name and maintained and provide information of a single organisation and is found on the internet. It is an HTML page/pages on the internet that contains information about an organisation

Hyperlink: - an area of a web page, usually text or image, that contains a links to another web page. It is usually underlined or has a different colour to show that it can link the user to another site.

Home page: A web page that loads first (by default) when one logs on to the internet. It then provides links to other sites on the internet. It is also a web page that appears first when you log on to a website.

URL: Uniform Resource Locator: This is a unique address that identifies a website/page on the internet, e.g. http://www.econet.co.zw. This only identifies one (unique) web page for Econet Wireless which is found in Zimbabwe (.zw). Thus a URL is a unique address for each web page. A typical URL looks like:

http://www.google.co.zw/computing/student.html.

This address has some a number of parts:
- http:// - protocol
- www. - host computer
- google.co.zw – Domain name and country
- computing – folder
- student. – Document name
- .html – document type (HTML type of document in this case)

- "http" (HyperText Transfer Protocol) and a domain name (such as ."co.uk"). Other domain names are as follows:

.zw	Zimbabwe
.za	South Africa
.zm	Zambia
.bw	Botswana, etc

Hardware Requirements for an Internet Connection

- **Modem (MOdulator DEModulator):-** a device that converts analogue data to digital form and vice versa, often for internet connection using a telephone line. Alternatively one may acquire a GPRS (general packet radio service) modem.
- **Communication link**: Acts as a transmission media for data, e.g. telephone line, satellite transmission, etc.
- **Network cards** for each computer:- a device that identifies computers to the network, has an interface where network cables are plugged on the computer

Software Requirements for an Internet Connection

These are: Communication Software, web browser and Network operating system

(a) Communication Software like TCP/IP – Transmission Control Protocol Internet Protocol. Allows devices to connect to the internet even if they have different manufacturer standards by use of pre-set rules or international standards.

(b) Web Browser: refers to software used for opening web pages on the internet, for example Microsoft Internet Explorer, Netscape Navigator, Mozilla Firefox, Opera, etc.

- **Web browsers are** used view web pages from the World Wide Web (www).
- A web page is a site (HTML document) on the internet that provides information about an organisation.
- The World Wide Web (www) is a vast repository of data stored on websites on the internet.
- Web pages can be created using any of the following software:
  - HTML (editor),
  - word processing package,
  - desktop publishing software,
  - web publishing software,
  - Presentation software.

Web Developing Software Features:

- Feature for changing the background colour or background image on a page.
- Feature for formatting text (size, font, colour, bold, italic, underline etc.) or frames.
- Able to work with tables.
- Features for inserting graphics/pictures/sound clip/video clip/animations.
- Features for working with links/creating buttons/list box.
- Features for switching to a browser to check the appearance of a page.
- Use templates.

Website features

The following are the general features of a good website

- shopping basket
- offer security when using credit/debit cards
- search facility for artist, tile, item, etc
- drop down boxes to choose categories
- help facilities
- currency converters for international customers
- date/sales confirmation by automatic email
- saved customer details/customised pages
- ability to track status of orders

- ability to listen to/view/see video/see product, etc
- recognise customer as soon as they log on
- buttons to navigate to other web pages

When designing web pages it is necessary to supply the correct spacing for customer information (and/or use drop down menus), buttons to navigate to other web pages, etc

(c) Network operating system: manages the network and offers security to internet users.

NB: <u>**internet account**</u>: a unique personal identifier given by the Internet Service Provider (ISP). An ISP is an organisation that links users to the internet, for example, Mweb, Ecoweb, Africaonline, Yahoo, Google Inc, etc.

Advantages of the Internet as a Source of Information
- Can be accessed from anywhere in the world.
- Information on the internet is up-to-date.
- Multimedia can be used.
- Huge amounts of information can be accessed; e.g., magazines, encyclopaedia, dictionaries, newspapers, textbooks, etc.
- Search engines are available to assist in finding information.
- Using emails you can access experts from all over the world on certain subjects.

Disadvantages of the Internet as a Source of Information
- Equipment and connections needed are very expensive (computers, modems (ISDN adapters) ISP, telephone).
- One needs knowledge to perform searches effectively.
- Problem of hackers.
- Breaches of copyrights are very common.
- Rampant spread of rumours on the internet.
- Spread of pornography to young people.
- Leads to loss of privacy.
- Some people become internet addicted and tend to interact with computers more than with human beings.
- Credit card fraud is rampant.
- Cultural erosion and replacement of local culture by a global culture

Searching information from the internet
- **Search Engines**: These are programs used to search data, information and other websites from the internet, e.g. Google, Yahoo, etc. however, it requires good skill from the user to efficiently use search engines in searching data from the internet.
- <u>**Hits**</u>: these are many irrelevant (unwanted) results that can be displayed by the search engine if the search engine is not used efficiently.
- To avoid hits when a search condition is entered, inclusion of statements such as AND (+) and OR will help narrow down the search. E.g. *ZIMSEC+syllabus.*

Internet and Security

Security is concerned with protection of data from unauthorised access and from deliberate or accidental loss.
Below are some of the security concerns and some suggestions on how they can be rectified / prevented.

Security Problem	Solutions / safeguards
Hacking	- Use of passwords and (usernames) ids to prevent illegal access to files. - Locking the computer itself or locking the computer room. - Encryption stops the information from being read even if access has been gained to a file but won't stop hacking!! - Installing firewalls
Viruses	- Use ant-virus software like AVG, Avast, Esat NOD32, etc, - Use firewalls to prevent viruses from entering a computer. - Do not open emails/attachments from "unknown" sources; - Only load software from disks/CDs which are originals
Corruption/Loss of Data due to the following ways:	
- viruses	Prevention of viruses is as given above
- hackers	- Prevention of hackers is as given above
- accidental damage to data	- Accidental damage to data can be prevented by: keeping back-up files or use the Grandfather-Father-Son (GFS) method; - use of passwords and ids can also help by restricting access in the first place
- hardware faults	- protection against hardware faults could be through keeping back-ups or use Grandfather-Father-Son; - use of UPS (Uninterruptible Power Supply), in case of power loss - Running parallel systems also help
- software faults	- Software faults can be solved by keeping back-up files or
- incorrect computer operation	- Can also be solved by using Grandfather-Father-Son would help - Incorrect computer operation can be solved by: backing up files would guard against problems caused by incorrect shutting down of the system

Definition of terms (from the table above)

Hacking: Obtaining unauthorised access to protected and secure computer systems or network, usually using intelligent methods like cracking the password.

Hacker: A person who gains unauthorised access to protected and secure computer systems or network, usually using intelligent methods like cracking the password

Virus: A computer virus is a program which replicates itself, damages or corrupts files and memory of the computer, for example, the Love Bug virus which attacked computers in 2000.

Anti-Virus: These are programs that detect and remove (clean) computer viruses and reduce the risk of computers being attacked by viruses, e.g. Norton Antivirus, MacAfee, Avira, Avast, AVG, etc.

Encryption: data encryption is the scrambling of data before sending, for security reasons, so that it is not readable unless it is decrypted using. However, some government do not allow encryption in their countries for security reasons against terrorism.

Back-up file: A duplicate (copy) of the original file that is created and stored at different location with the original file, for security reason.

Grandfather-Father-Son files: Also called file generations: these are three versions of files that are kept at an organisation and are created as a result of sequential file updating and are used for data recovery when the current master file is lost.

UPS: Uninterruptible Power Supply (A device with rechargeable batteries that provide continuous supply of electricity to computers for a given period of time if there is power cut.

Parallel systems: Refers to the running of two different systems but doing the same job in the same organisation. Each system will have its own files.

Password: A password is a secret group of alphanumeric characters used to protect a document or file from unauthorised access

PIN: Personal Identification Number- a secret number used by individual account holders to access bank account and get service at the ATM, phone, Point of Sale terminal (POS) using debit cards, etc.

Firewall: Hardware and associated software used to protect networked private computer systems from unauthorised access by preventing outside data/users from entering the system while at the same time preventing internal data from leaving the system.

Other internet threats include:
- **Phishing** is a way of fooling someone into handing over the security details for their bank account. The phisher sends an email that looks as if it comes from the recipient's bank and contains a link to a website controlled by the phisher. It can be prevented by not clicking on the link and instead going to the bank's website directly.
- **Spam** is unwanted email, often advertising products or services. It can be prevented by using an anti-spam filter, which is oft en provided automatically by an ISP.
- **Pharming** is an attack by hacking. It intercepts a browser request and redirects it to another website on which the attacker attempts to steal authentication credentials or debit or credit card details, as in a phishing attack. It can be discouraged by changing the password on a router (especially a wireless router) so that the hacker cannot redirect the DNS information.

NB: Note
- Viruses do not only infect computers, they can also affect mobile phones, MP3 players etc. − any device which can download files from a source such as the internet is potentially at risk.
- Backing up may allow files that have become lost/corrupted (due to hacking or viruses) to be reinstated; however, this would not recover the system nor would it prevent hacking/viruses affecting a system in the first place.
- Problems like spam, pop-ups, cookies, etc. are more of a nuisance (they can also slow down the operation of a computer). These can however be blocked (or made inactive) by using suitable software.

When using the Internet, security can be enhanced using encryption.

Credit and debit card transactions can also be protected by a special type of password control.

For example, if a user chooses the password COMPUTE34 to protect their credit card, when they buy something over the internet the card issuer will ask the user an additional question such as: "Please type in the 2 , 4 and 7 character of your password in the following boxes:

<div align="center">□ □ □ "</div>

The user will then type in O P E and the card purchase will be authorised. This additional protection is used as well as encryption.

Some of the new systems allows user slots the card into the side of the keyboard and is required to type in a PIN before the Internet can be accessed. This gives an additional level of security since it is necessary to have the card, know the PIN associated with the card AND also know the user's log in id and password!!!

People's fear of the Internet

People's worries about the risks when using the Internet include:

- Encountering offensive websites while searching for goods or services, e.g pornographic sites, sites with hate language, etc.
- downloading viruses during a transaction
- being deceived by a bogus website and paying for counterfeit or non-existent goods
- interception of shopping account, card payment or banking account information making them vulnerable to unauthorised access to their accounts ('hacking') or fraudulent transactions
- Browser 'cookie' files identifying their computer to a web server, enabling a trader to 'retarget' them.
- receiving unsolicited email after they have been required to supply a valid email address in order to register for an account
- Erosion of local culture by global culture.

Services Provided by the Internet

1. Electronic Mail (E-Mail): A form of communication in which written/typed messages are send electronically over networked computers. In-order to send and receive e-mails, the following is needed.

(a) An internet connection

(b) An E-mail Address for both the sender and receiver:
- This is a unique identifier of the storage location of a person's mailbox.
- An e-mail address is made up of two parts that are separated by the "@" symbol, for example, kapondenit@gmail.com.
- The first part (kapondenit) is the username and is used to identify the name of the person or organisation that has the mailbox. The username is unique.
- The second part (gmail) is the domain name and is used to identify the server where the person has a mailbox.
- The other part (the one after the dot (.) indicates the domain type e. g
  - . com – commercial organisation
  - . edu – educational organisation
  - . org – non-profit making organisation, etc
- An e-mail address should be known by many people so that they will know the address where to send the emails.
- Every mailbox is protected from illegal access by use of password.
- A **password** is a secret group of alphanumeric characters used to protect a document from unauthorised access.
- **NB.** When creating an e-mail, one is requested to enter the password twice in order to verify if it is the one you intend to use.
- **Mailbox**: - An electronic folder used to store electronic mails. It contains the inbox; which contains incoming mails; and the outbox; which is used to save outgoing messages.

Process of sending e-mail
- the user first logs on to email address,
- the sender composes the message and attaches a file (if required)
- The user then sends it by clicking on the send button.
- The message is transmitted to the sender's ISP/central host server.
- The message is stored on a central host computer of the sender.
- The mail server examines the address of the message
- The message is transmitted to the recipient's ISP mail server
- The message is stored in the recipient's electronic mail box.
- The addressee logs in to a local computer and receives the mail

Reading/retrieving the message
- the recipient logs on to their mail server
- the message is then retrieved from the inbox and sent to the recipient's computer

- the recipient reads own message (can be printed if there is need)

Advantages of e-mails as compared to ordinary mails

- It is very fast in sending messages (can be delivered promptly while ordinary mails can take days to reach their destination).
- It is very cheap to send e-mails since there is no need for envelopes, stamps, paper and pen, which are needed in conventional mail.
- They are reliable since e-mails rarely get lost.
- E-mails are time independent as they can be send any time of the day other than conventional mails which can be send during the normal working hours.
- E-mails allow multiple addressing, that is, one e-mail message can be send to several recipients simultaneously without having to retype it.
- E-mails can be saved for future use or reference.
- E-mails are more convenient to use as there is no need to travel to the post office or to shops to buy stamps and envelopes.
- In e-mails, attachments in form of reports, scanned documents, pictures and curriculum vitae can easily be attached to the e-mail.
- there are no language problems (systems can translate messages sent)
- - it is possible to read emails whenever you want – there are no issues of time differences as would be the case with video conferencing. If some delegates lived in the USA and the others lived in India, for example, the time difference is 10 to 14 hours which could be a problem)

Disadvantages of e-mail

- Not everyone has equipment to send e-mails.
- Junk mail (spam) is a problem.
- You waste a lot of time looking through mails that are just adverts.
- E-mails are not as secure as traditional mails.
- The system relies on people checking their mails regularly.
- Old people feel left out as they consider themselves too old to learn.
- Equipment used to send and receive e-mails is very expensive as compared to traditional methods.

However, despite the increase in the use of e-mail, there has been a sharp increase in the amount of paper used. This is because:

- People print copies for meetings and then destroy them afterwards, but if needed again, print out another copy.
- Some people find it difficult reading large amounts of text on the screen.
- People often e-mail colleagues rather than use the phone who then print out the document.

2. Teleconferencing: A method of conducting discussion with several people in different locations using the telephone.

3. Video conferencing: Conducting meetings with several people in different locations and seeing each other on the screen of networked computers. Video images and audio are seen/heard in real time on large monitors/through speakers. Delegates do not need to leave their homes or work places or conference rooms. Video conferencing requires the following:

- A computer with a codec (which converts and compresses analogue data into digital data for sending down digital lines.)
- Video cameras or Webcam to take video images
- Microphone to speak through.

- Loud Speakers for delegates' voices to be heard.
- Large and high resolution monitor.
- Internet/WAN/modem to transmit data
- An integrated Services Digital Network (ISDN) line with a high bandwidth to transmit video data at fast speed.
- Sound card.
- Video card
- Compression software to compress video and sound
- which converts and compresses analogue data into digital data for sending down digital lines
- requirement for echo cancellation software (this allows talking in real time and keeps communications synchronised)

How the video conferencing is done
- delegates, while in different locations, speak into central microphone
- webcam takes video images in real time
- delegates hear speech through loud speaker system
- system uses internet/WAN/broadband modem to transmit data
- uses of compression software/CODEC
- use echo cancellation software

Advantages of tele and video conferencing
- It cuts transport cost incurred in travelling to the venue of the meeting.
- Reduces costs involving paying hotel bills and meals for the delegates.
- Saves time spend in travelling to the venue of the meeting.
- It becomes safer for employees since no travelling is done (no travelling accidents).
- There is no need for delegates to leave home/office.
- It becomes easier for several delegates to take part simultaneously.
- communication links are now much faster therefore images, sound quality etc. are now far better
- safety reasons (increase in world-wide terrorist activity, frequent travelling, etc. are all risks to company employees if they have to travel to meetings)
- improvements to the work/general environment (employees can work from home,
- Less travel means less stress to employees but also means less pollution, disabled employees are no longer disadvantaged, etc.
- more economical to have short notice meetings

Disadvantages of video and tele-conferencing
- Communication expenses are very high.
- Hardware and software requirements are expensive.
- People will lack personal contact and will socialize less.
- The hardware and software needed to run video conferencing is very sophisticated and expensive.
- Confidential documents may need to be seen in their original form, which may be difficult in this situation
- There is no direct eye contact, which plays a large role in group discussions.
- The quality of video or audio may be low, depending on the bandwidth.
- There may be interruptions due to breakdowns in transmission
- Power cuts may prevent the conference from continuing.

4. View data (videotext) systems: These are interactive systems on which users view data when they access specialized databases like Prestel. The requirements include:
- the telephone line or cable TV,
- specialized keyboard and

- A Television set.

Information on the database is provided by companies that advertise their products like news, weather reports, and so on. View data systems have the following advantages:
- they are interactive and
- service is provided for free to the public.

However, its requirements are expensive.

5. Teletext: It is a broadcast service that comes as a television transmission. It is cheaper than the internet service. However, it is non-interactive.

6. Facsimile (Fax): A method whereby output from a scanned document is send over telephone line and reproduce on a fax machine on the receiving end. Fax method has the following advantages:
- It is very cheap to send messages.
- It is very easy to use.
- It is a very fast method of sending messages.

However, it has the following disadvantages:
- Its requirements are expensive (fax machine).
- There must be a person at the receiving end to attend to the fax when receiving messages.

NB: The use of fax, e-mail, view data, teletext, teleconferencing and video conferencing in an office brings about an electronic (paperless) office.
- An electronic office is an office in which the storage and processing of data as well as communication are done electronically.
- An electronic office is efficient because:
  - Communication is easier and faster.
  - Less paperwork is involved.
  - Current and up-to-date information is provided.
  - Ensures a clean office environment.

However, it is very expensive to setup and maintain an electronic office.
****NB**- The use of computers to perform all clerical and office duties is called Office Automation.
- Tele and video conferencing as well as networking bring about **tele-commuting** (tele-working). Tele-commuting is carrying out work without leaving home.
- Communication is done through networked computers.
- Requirements for telecommuting includes: modem, very fast communication links (for example telephone line), computers, internet services, etc.

Benefits of telecommuting
- Easier to concentrate on work in a quiet environment than in a noisy office.
- It saves time spent in travelling to the work place thereby increasing productivity.
- It cut costs involved in travelling to work place.
- The employer saves costs of office space and overheads like water and electricity.
- People can be recruited from a wide geographical area.
- People with disabilities like the handicapped can be employed.
- People in different locations can work as a team.

Disadvantages of tele-commuting
- Workforce not in office is difficult to control.
- Workers would not understand corporate goals and will not be loyal to the organisation.

- Employees feel isolated and miss the environment of an office full of colleagues.
- People may find it difficult to work in teams.
- It is difficult to separate work from home duties while at home.
- Unions find it difficult to mobilise workers for demonstrations and strike.

7. File Transfer : allows users to transfer files from host computers on the internet to their personal computers.

8. News groups: a global electronic bulletin board system in which users exchange information on different topics.

9. Entertainment: the internet provides an option for users to download and listen to music, newspapers, radio stations, etc.

10. Internet Shopping: (Internet buying, electronic commerce, online shopping): The internet provides a facility for customers to purchase products from the internet without visiting shops. Credit cards are used in internet buying.
<u>**Advantages of buying from the internet**</u>
(a) To the customers
- Programs are available to search for the cheapest products on offer.
- Customers have more time to choose.
- Shopping is done any time of the day, thus providing a 24 hour service.
- A wide choice of products is available.
- Shopping can be done by setting up a file.
- It is very convenient to use as customers do not leave their homes for shopping.
- It cut travelling costs to the shops.
- Customers do shopping without being jostled by crowds.
- There are less cases of impulse buying.
- Product reviews are obtainable before purchase.
- Goods and services usually cheaper on the internet.
- Customer need not to go to shop and therefore save travelling time.

(b) To businesses/shop managers
- Business is carried out any time of the day (provides a 24 hour shopping service).
- Increases sales due to greater number of customers from all over the world.
- No wastage space for goods is involved.
- Ensures huge saving on overheads like rent, warehousing, employee facilities.
- More goods can be made available.
- It is cheaper to use as there are no leaflets, pamphlets, etc.
- Can reduce the number of shops on the streets.
- Organisations can employ fewer workers thereby cutting labour costs.
- No need to travel to the shop as business can be run from home.

<u>**Disadvantages of buying from the internet**</u>
(a) To customers
- There are chances of losing money through credit card fraud and hacking.
- Customers lack interaction with others.
- Customers fear of rogue companies (customers may not receive the goods).
- Customers cannot physically see the goods before purchasing.
- Not everyone has a computer and is connected to the internet.
- Not everyone has credit cards.
- Problem of spam (Unwanted e-mail, usually of a commercial nature sent out in bulk).

- Customers cannot have the goods immediately.

(b) To businesses
- Increase in cases of industrial espionage.

Industrial espionage involves selling of company secrets by employees to rival companies and the use of destructive methods by competitors to destroy other organisations.

Effects of E-Commerce and E-banking To the Community

Positive effects	Negative effects
Shops and banks are open 24/7	Close down of shops/banks in city centres
Access to shops and banks is worldwide	Increased risk of fraud/hacking
Less pollution since less travelling	Less personal service/more impersonal
Disabled people are not disadvantaged (no need to travel)	Loss of jobs due to closures of shops/banks
Busy people can shop/bank when they want and where they want	Less social interaction between people – just sit at home using computer
If you live in a remote area, it is much easier to access shops/banks	Less activity for people – leads to a less healthy/overweight population
Less expensive (cost savings to shop/ bank + more competition – savings are passed on to the customer)	Less environmentally friendly since more goods sent out by post – waste from packaging significantly increases
Less money is spent in travelling	The gap between the rich and the poor widens as the rich get savings from shopping on-line.
Increase in small businesses.	Lower profits for companies that do not engage in e-commerce.
Decline in leisure shopping as goods are bought on-line.	deskilling of the work force (e.g CAD has taken over draftsman skills, word processors have taken over many office-based duties, etc.)

A lot of money is wasted by the need to re-train the workforce in the use of new software/computers

Computer systems have allowed companies to set up call centres in other countries where potential cost savings can be made. This, of course, can lead to job losses in the host country.

Advantage to companies adopting call centres overseas includes:
- if strikes or other problems occur in one country it is possible to transfer work elsewhere
- reduced costs in countries where labour costs are lower
- reduced costs due to incentives/grants by countries keen to set up call centre offices
- round the clock customer support (one of the **advantages** of time differences is the possibility of 24/7 cover)

Disadvantages to having call centres overseas:
- language and culture problems
- animosity (hatred/enmity) to overseas call centres (leading to loss of customers)
- need for extensive re-training which is time consuming and expensive
- time differences (can lead to health problems in call centre work force who need to work unsocial hours to target key markets)
- Technology differences between different countries (does the infrastructure exist to service high tech equipment?)

The Cashless Society
This refers to the paying for goods and services without the use of notes and coins. It is the use of electronic commerce thereby reducing handling of hard cash amongst individuals.

However, it seems impossible to completely have a complete cashless society. Services that contribute towards a cashless society include:
- EDI (Electronic Data Interchange)- is an electronic communication system that provides standards for exchanging data via any electronic means, e.g. purchase orders, invoices, shipping notices, etc.
- Mobile banking
- Mobile money transfers-Ecocash, Telecash, OneWallet, etc
- Internet banking
- Electronic commerce/internet buying
- EFTPOS-Electronic Funds Transfer at Point of Sale.
- Credits cards/debit cards, coupons, etc

Benefits of A cashless society
- More convenient to pay bills, mortgage loans, gas, phone and electricity bills since these are paid automatically.
- Customers no longer need to carry large sums of money thereby reducing cases of robbery.
- Customers no longer need to queue on banks to get cash.

Problems of a Cashless Society:
- Credit is normally given only to those who are working and have a steady source of income.
- People will spend more than they can afford thereby getting into debt.
- Wrong information about individuals is kept as more information about people is kept in computers for their credit rating.
- It is difficult for individuals to track how much they spent.

Intranet

- Intranet stands for INTernal Restricted Access NETwork.
- Intranet refers to a restricted private organisation's network that uses the same protocols as internet for the benefits of such an organisation.
- An intranet is a computer network based on internet technology that is designed to meet the internal needs for sharing information within a single organisation/company
- Intranet requires password entry.
- Intranet is protected by a firewall.
- Intranet only gives local information relevant to the company/organisation
- It is possible to block access to certain sites using the intranet, e.g Facebook.
- it is not always necessary to have external modems when using intranets
- information for use on intranets is stored on local servers

Many companies use intranets as well as the internet for the following reasons:
- it is safer since there is less chance of external hacking or viruses
- it is possible to prevent employees from accessing unwanted web sites
- companies can ensure that the information available is specific to their needs only
- it is easier to keep "sensitive" messages to remain within the company only

Differences between internet and Intranet

Internet	Intranet
the INTERNET is INTERnational NETwork	an INTRANET is INTernal Restricted Access NETwork
Internet gives all information including that which is not relevant to the organisation	the intranet only gives local information relevant to the company/organisation
Always need external modems for internet connections	it is not always necessary to have external modems when using intranets

Information on internet saved in different computers	information for use on intranets is stored on local servers
the internet can be accessed from anywhere	Intranet is accessed within the range of the organisation's network
the internet is available to anyone without password restriction	whereas the intranet requires password entry

Extranet: It is an intranet made available off -site to members or business partners of an organisation. It is an extension of the intranet giving authorized outsiders controlled access to the intranet.

Wireless Technology (WIFI) and Broadband

Broadband: a communications network that provides for high quality and high speed voice, data and video transmission usually over one channel in wireless networks or over high bandwidth media like fiber optics and satellites.

Wireless Communication:
This is a method of networking (linking) computers and computer devices without the use of cabling (wires), e.g. using Bluetooth, radio, satellite, infra-red, microwave, etc. The devices that can be used in wireless technology include:
   - Mobile phones /cell phone/remote key pad/remote control/ remote keyboard.
   - Infra-red mouse.
   - Multimedia mobile handsets and notebooks.
   - GPRS (General Packet Radio Service) modems.
   - Wireless LAN(or Wi-Fi –Wireless Fidelity: A local area network that uses high frequency radio signals to transmit and receive data over distances of a few hundred feet; uses Ethernet protocol).
   - PDAs (personal digital assistants).

Advantages of wireless communication
   - Cheaper as no wires are needed for networking.
   - Ensures fast wireless Internet access.
   - Wireless LAN is faster than a modem or mobile.
   - Wireless LAN enables working at home.
   - Users can create and send multimedia messages to mobiles or e-mail while in transit.
   - Users can send greetings from mobiles to mobiles/PCs.
   - Ensures instant transmission.
   - Users can download e-mail and file attachments while on mobile. Users can watch live web cast on mobile.
   - Users can listen to streaming video on mobile.
   - Users can watch news, weather, sport, games while travelling.
   - Users can access information from mobile anytime.
   - Users can send, receive, delete e-mail while travelling.
   - Users can view business appointments while out of office on mobile.
   - Users can send corporate e-mail while out of office - even behind a firewall on mobile.
   - Users can use wireless internet connection from chat rooms for discussions with colleagues while travelling.

Most areas in the world now offer broadband rather than dial up for connecting to the internet. The advantages of broadband over dial up include:

- the system is always "on"-no need to dial into ISP every time you want access
- the connection rate/data transfer rate is much higher (for example broadband operates at 11 000 kbps compared to the dial up rate of 60 kbps)
- there is a flat monthly rate with broadband (dial up is charged per hour of usage)
- it is possible to use the telephone at the same as the internet with broadband/the line isn't tied up
- broadband permits other facilities such as "skype"
- Wireless technology (WiFi) allows connection of a computer to the Internet without the need for connecting cables. A router (containing a modem and external aerial) is connected to a telephone line and it is then possible for any computer within range to communicate with the router and allow Internet access – the link between computer and router is completely wireless.. The main advantage of doing this is clearly the portability (i.e. can go anywhere within range since no wires are needed).

Disadvantages of Wireless Technology
- Wireless LAN speeds are slower than Net access at work due to narrow bandwidth.
- Anyone within the Wireless LAN nodes range with an appropriate device can use your Wireless LAN and broad band link.
- Anyone who walks past your house or WLAN linked into a corporate system can access sensitive information like credit card details.
- 3G phones are not compatible with 2G phones.
- Signals can be blocked, distorted or will be weak.
- Can lead to health problems from microwaves
- the range can be very limited, e.g. using Bluetooth.
- possible interference from nearby electronic devices
- security issues (i.e. tapping illegally into WiFi networks) is very common
- access speed/transfer rate is often slower using wireless systems

It isn't just computers that can be linked without wires, various peripheral devices can be linked to a computer system without the need for a physical, wired connection. For example: Printers, Keyboards, Mouse, Digital cameras, etc

Computers in Entertainment

Music
Computers are now used for playing and composing music. Computer hardware and software advances have changed how music is generated and produced. Software used includes Fruit Loops, Virtual DJ, etc.
Musical instruments can be connected to a MIDI (Musical Instrument Digital Interface).
MIDI is a type of serial interface built into a piece of electrical equipment so that it can communicate with the computer. It also converts output signals from the instrument, e.g. guitar, into digital form.
Some of the key reasons for the widespread development of music using computers are:
- the recording process for music is faster
- there is no need for tapes during the recording process
- It is easier to remove or add sounds to a track.
- Sampling of sounds is very easy
- actual musical notes can be generated from the music itself by software
- music samplers and mixers give an almost limitless ability to alter the original tracks recorded in a studio
- don't need to understand music notation to write a musical score
- electric instruments (such as guitars and organs) play back through electronic machines
- synthesisers combine simple wave forms to produce more complex sounds

- electric organs can now mimic almost any instrument (including a full orchestra)
- automatic rhythm
- music notes automatically printed out in the correct format
- There are many other software and hardware developments; the above is just a summary of the more common elements.
- A performance can be directly recorded onto the computer and stored in a MIDI file, which can be edited later.
- Synthesisers are also used to generate notes and desired sounds from pre-recorded electrical signals. These signals can be combined with signals from conventional instruments and recorded to produce songs.

Music can be compressed to produce MP3 (motion picture expert) format.

Music can be played using software like Microsoft Windows Media Player, JetAudio, Nero Show Time, Real Player, etc.

Animation/Cartoons in Films and Video/Television

Computer Graphics

These are computer generated images designed by graphic artists for producing logos, news inserts, cartoons, animations, etc. The artists use graphic software like Microsoft Paint. 3-D images can also be produced using graphics packages.

Image processing: The images can be darkened, sharpened, changed colour, cropped, etc.

Animation

- Animation consists of displaying a rapid succession of 2-D or 3-D graphics arrangements to create the illusion of movement. It is used for web presentations and advertisements and for film.
- Computer animation is the art of creating moving images via computer hardware and software.
- Sounds can be added to the animation to produce advertisements, cartoons and films.
- Computers with large hard disk and powerful processors are needed, as well as high resolution monitors
- Special effects in many modern films (televisions) all use computer animation to produce fantasy worlds.

Computer Based Training (CBT)

- CBT makes use of a computer system to train people in a number of applications.
- It makes use of multimedia and self-assessment with minimum input needed from a human trainer.
- The advantages of training people using computer systems (such as CBT) include:
  - trainees can work at their own speed
  - trainees can learn when they want
  - it is possible to re-run sections of the training program if necessary
  - possible to come back at any time/pause training program at any point
  - user gets immediate assessment of performance
  - possible to include multi-media elements in the training package
  - no need to have a teacher/classroom – potential cost savings therefore possible
  - it is easier to keep up to date/amend

Automatic Stock Control System in a Supermarket
At the POS terminal, the hardware required includes:
(a) **Input Hardware**:
- **barcode reader** (automatically enter details of goods purchased into the computer by scanning them),
- **keyboard** (manually typing in product code if the barcode reader fails to do so),
- mouse (selecting item by clicking)
- **touch screen**: for selecting menu and entering data into the computer
- **swiping machine**: for entering PIN and swiping debit cards

(b) **Output Devices**:
- **printer** (producing receipts),
- **monitor** (VDU) -displays item details and items that are being purchased by the client, amount paid and change

(c) Communication devices
- **Network Cables**: connecting the VDU to the main computer in the manager's office
- **Telephone line/high distance communication link**: for online linkage of the POS terminal and the bank.

Procedure of automatic stock control
- bar codes are attached to all goods/items sold by the supermarket as a means of identification
- each bar code is associated with a stock file on a computer database
- the customer takes their basket/trolley to the POS terminal
- the bar code on the product is scanned at the point of sale (POS) terminal using the barcode reader
- if the bar code can't be read, the POS operator has to key in the bar code number manually using a keyboard/key pad
- the bar code is searched from the database
- once the bar code is identified/found, the appropriate file/record is accessed
- the price of the good/item is found and sent back to the POS
- the stock level of the item is reduced by 1
- if the stock level is less than or equal to the re-order/minimum stock level then the system automatically re-orders goods/items from the suppliers
- this procedure is repeated until all the items in the customer's basket/trolley have scanned
- when all items/goods have been scanned, the customer is given an itemised bill showing a list (with prices) of everything they have bought
- the computer also updates the files containing the daily takings
- if the customer has a loyalty card, the system automatically updates their points total
- when new goods arrive, the bar codes are used to update the stock files
- some newer supermarkets now allow customers to scan their own basket/trolley and pay for the items/goods using credit card or cash (essentially the stock control system is the same for both methods)

The POS terminals can also be connected to the main server in banks like CABS, Barclays, etc. This enables customers to purchase goods electronically without the burden of carrying cash around. This is called **Electronic Funds Transfer at Point of Sale (EFTPOS).** Customers can also be given cash back at the EFTPOS after purchasing goods using debit cards.
After purchasing the goods, a receipt is produced. The receipt will have the following details:

- date of purchase, time purchased, shop attendant, item (s) bought, quantity bought, unit price, total price, amount tendered, change, cashier name, etc.

Advantages of Electronic POS terminal to supermarket workers
- no need to remember (memorise) price of goods
- their work load is reduced
- ensures accurate calculation of customer change
- ensures better working environment which means less stress
- fast means of entering data which is less manual

Advantages of Electronic POS terminal to customers
- customers are served quickly
- customers are assured that their change is correctly calculated
- customers can get cash back if the POS is linked to banks
- no need for customers to carry cash around once the system is linked to banks thereby reduces theft of their cash

Advantages of Electronic POS terminal to supermarket managers
- It is automatic and more accurate to control stock.
- Automatic updating of stock file is ensured.
- Automatic reordering of stock items is involved.
- Less staff and wages needed.
- Sales statistics are always available.
- Faster throughput is ensured.
- Itemised receipts are produced quickly.
- The system records every transaction.
- The system records staff work rates.
- Less pilfering by staff as it is easier to identify pilfering.
- Fewer errors are produced. Faster calculations are made.
- There is no need to remember prices of goods.
- Manager is freed from the task of manually counting the stock items and placing some orders.

NB. The system updates the master file when an item is sold. It first searches the master file. Using the barcode number (or product code) it decrease the number in stock and increase the quantity sold

*NB: POS –Point of Sale terminal: the point where customers pay for goods purchased in shops, either by cash or otherwise.

Difference between Electronic Point Of Sale (EPOS) and Electronic Funds Transfer at Point Of Sale (EFTPOS).

EPOS terminal only involves scanning of goods electronically by use of barcodes and by keyboard entry. **EFTPOS** involves electronic scanning of goods at point of sale by use of scanners and barcodes (and use of keyboard) and has an added feature of allowing customers to transfer money from one account to another, usually to the account of the shop where the goods are being bought. Customers can also get cash-back at the EFTPOS terminal in shops.

BASIC BINARY OPERATIONS

***NB**. Could not compile notes on this as most, if not all, of the concepts are covered in Mathematics. However pupils should be able to perform the following:

(a) Using up to 8 bits
- Convert denary numbers to their binary equivalent
- Convert binary numbers to their denary equivalents
- Adding binary numbers together

- Subtraction of binary numbers

LOGIC GATES

- A logic gate is a device that produces signals of 1 or 0 when the input logic requirements are met and are used in manipulating binary information.
- Logic gates are the building blocks of digital technology. A logic gate is a device (or electrical circuit) that performs one or more logical operations on one or more input signals. Its output represent **Boolean** (T or F) or binary values (1 or 0) as voltages.
- They can be used in applications like:
    - Building computer chips, Programming traffic signals, Chips for automatic alarm systems, Chips for automated control systems, etc
- Electronic circuits operate using binary logic gates.
- Logic gates process signals which represent **TRUE** or **FALSE, ON** or **OFF** , **1** or **0**

Main Logic Gates

The main logic gates are:

    (a) OR gate
    (b) AND gate
    (c) NOT gate
    (d) NOR gate
    (e) NAND gate

Logic gates are used with **truth tables**.

- A *truth table* is a table which shows how a *logic* circuit's output responds to various combinations of the inputs, using *logic* **1** for true and *logic* **0** for false.
- A truth table is a table that describes the behaviour of a logic gate.
- It lists the value of the output for every possible combination of the inputs
- Truth tables contains 1s and 0s and are an integral part of logic gates functionality.
- Truth table and logic gates use the following:
- 1 (True, ON, Not False)
- 0 (False, OFF, Not True)

    The number of rows in a truth table shows the number of combinations of the inputs of a particular circuit. The number of rows for each gate is found using the following formulae: rows $= 2^n$, *n* being the number of inputs in the gate or circuit. For example, a gate or circuit has the following rows corresponding to the number of input (excluding column headings):
- 1 input $= 2^1 = 2$ rows
- 2 inputs $= 2^2 = 4$ rows
- 3 inputs $= 2^3 = 8$ rows
- …..

Graphical Representation of Gates and their Truth Tables

Each logic gate has its own unique graphical representation, which can be in general form or in standard form.

(1) General form

Each logic gate has a circle and the name of the gate to differentiate it from the rest as given below:
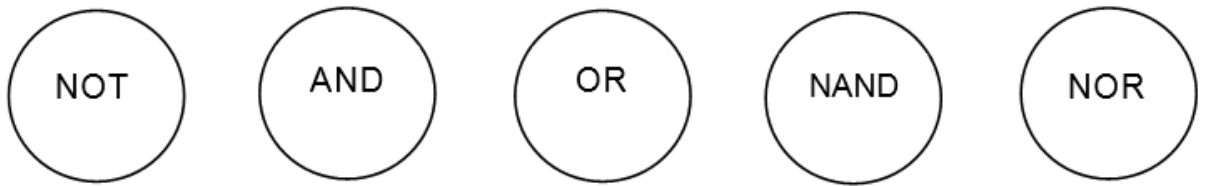
The name inside the gate gives us the type of the gate

(2) Standard Representation

In standard form, each logic gate has its own unique diagram. Even if the name of the gate is not written, one knows what it stands for because of the shape. The following are the logic gates and their shapes in standard form.

(a) OR gate
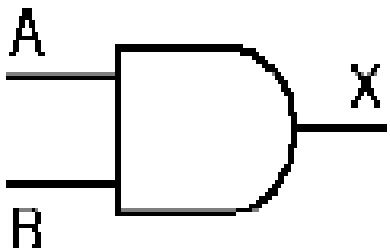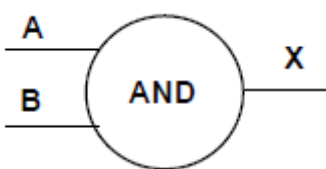
This represents two inputs entering the gate and one output from the gate. The inputs can be represented by **any** alphabetic characters, e.g. A and B, while the output can be X, given as follows:

Logic Gate Diagram		Truth table
Standard Form	**General Form**	
		<table><tr><td>A</td><td>B</td><td>X</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>

- X= A **OR** B
- The output (X) is **true** if the **INPUT A OR INPUT B** are **true.**
- Thus if any one of the inputs is 1, the output is automatically 1
- Output only becomes 0 if all inputs are 0
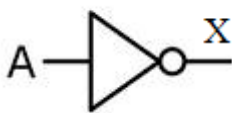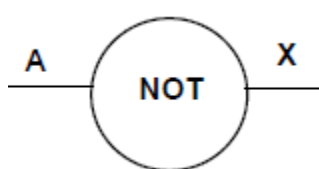
(b) AND gate

This is represented as follows:

Logic Gate Diagram		Truth table
Standard Form	**General Form**	

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

The output (X) is only **true** if the **INPUT A AND INPUT B** are both **true**. If any one of the inputs is 0, then the output becomes 0 also. Thus X = A **AND** B.

(c)   NOT gate
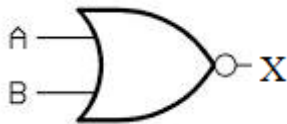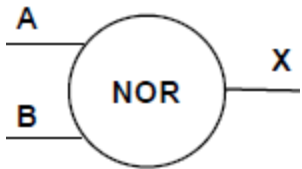
Logic Gate Diagram		Truth table
Standard Form	**General Form**	

INPUT A	OUTPUT X
1	0
0	1

The **NOT** gate has **only** one input and one output. The input is negated. Thus if input is 1, output is 0, and vice versa.

The output (X) is **true** when the **INPUT A** is **NOT TRUE**.

The output (X) is **False** when the **INPUT A** is **TRUE.**
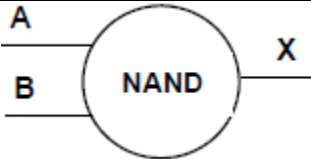
(d) NOR gate

Logic Gate Diagram		Truth table
Standard Form	**General Form**	

INPUT A	INPUT B	OUTPUT X
1	1	0
1	0	0
0	1	0
0	0	1

-    This is an **OR** gate with the output X inverted.

- The output (X) is **true** if **NOT** (**INPUT A OR INPUT B**) are **true.**
- Thus X = NOT (A or B)

(e) NAND gate

Logic Gate Diagram		Truth table		
Standard Form	**General Form**			

INPUT A	INPUT B	OUTPUT X
1	1	0
1	0	1
0	1	1
0	0	1

This is an **AND** gate with the output X inverted. The output is **true** if **INPUT A AND INPUT B** are **NOT** both **True.** It translates to NOT (A and B)

Combinational Logic Gates

A combination of logic gates, which may be different, gives a logic circuit as given below:
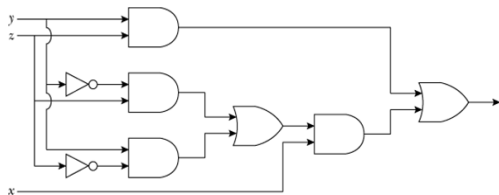
Boolean Expressions

Boolean Expressions are equivalent expressions of the logic state of gates. For example, the Boolean expression for:

a **NOT** gate with input A and output C: C = **NOT** A

NAND and NOR gates are known as **universal gates** because they are inexpensive to manufacture and any Boolean function (AND, OR, NOT) can be constructed using only NAND or only NOR gates. Even NAND and NOR gates can be used as each other's alternatives in a circuit.

Expressions and Logic Gates

Expressions using mathematical symbols can be used to represent logic gates. One may be required to draw logic gates using such mathematical expressions Such symbols and their meaning are as given below:

1. **Plus sign** (+)
   - This means OR, e.g.
   - C= A + B
   - This is an OR gate, which means C = A OR B.
2. **Multiplication Sign**
   - This represents an AND gate
   - E.g C = AB,
   - C = AxB,

- C = A.B
- C= (AB)(AC)
- C = (A.B).(A.C)
- All these are various versions of the AND gate.

3. **Complement sign (' or – above an input)**
   - This represents a NOT gate
   - For example: NOT A can be given as any one of the following:
     - A'
     - $\overline{A}$

Logic Gate Problems:

Question: Worked Example

A steel rolling mill is to be controlled by a logic network made up of AND, OR and NOT gates only. The mill receives a stop signal (i.e. S = 1) depending on the following input bits:

INPUT	BINARY VALUE	CONDITION
L	1 0	Length > 100 metres Length $\leq$ 100 metres
T	1 0	Temperature < 1000 C Temperature $\leq$ 1000 C
V	1 0	Velocity > 10 m/s Velocity $\leq$ 10 m/s

A stop signal (S = 1) occurs when:

> Either: Length, L > 100 metres and Velocity, V < =10 m/s

> Or   Temperature, T <=1000 C and Velocity, V >10 m/s

Draw a logic network and truth table to show all the possible situations when the stop signal could be received.

Answer

### Step 1: Deduce and Write the logic statement

- The first statement can be re-written as: **(L = 1 AND V = NOT 1)** since Length > 100 metres corresponds to a binary value of 1 and Velocity <=10 m/s corresponds to a binary value of 0 (i.e. NOT 1).
- The second statement can be written as (T = NOT 1 AND V = 1)
- Both these statements are joined together by OR which gives us the logic statement: if (L = 1 AND V = NOT 1) OR (T = NOT 1 AND V = 1) then S = 1
- The above statement can be written as: S = 1 if (L = 1 AND V = NOT 1) OR (T = NOT 1 AND V = 1)

NB: the Student should first of all write the following logic statement before coming up with a truth table or logic circuit as this has some marks awarded to it., i.e.

> S = 1 if (L = 1 AND V = NOT 1) OR (T = NOT 1 AND V = 1)

Step 2: Logic Circuit

- Using the logic statement above, one can now draw the logic circuit as given below:
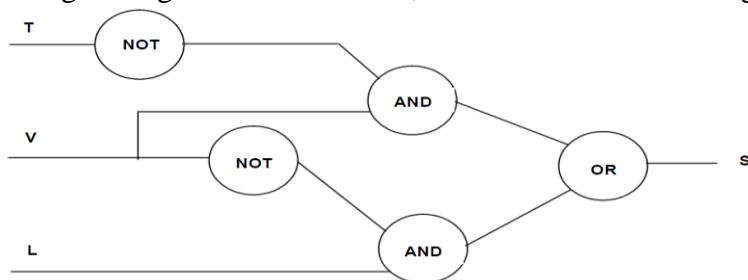
Step 3: Truth Table

- One can now draw the truth table, basing from the logic statement in Step 1.

L	T	V	S
1	1	1	0
1	1	0	1
1	0	1	1
1	0	0	1
0	1	1	0
0	1	0	0
0	0	1	1
0	0	0	0

Questions

1. A computer will only operate if three switches P, S and T are correctly set. An output signal (X = 1) will occur if R and S are both ON or if R is OFF and S and T are ON. Design a logic network and draw the truth table for this network.

2. A traffic signal system will only operate if it receives an output signal (D = 1).

   This can only occur if:

   Either   (a) signal A is red (i.e. A = 0)

   Or   (b) signal A is green (i.e. A = 1) and signals B and C are both red (i.e. B

   and C are both 0)

Design a logic network and draw a truth table for the above system.

3. A chemical plant gives out a warning signal (W = 1) when the process goes wrong. A logic network is used to provide input and to decide whether or not W = 1

Input	Binary Value	Plant Status
C	1	Chemical Rate = 10 m^3/s
	0	Chemical Rate < 10 m^3/s
T	1	Temperature = 87 C
	0	Temperature > 87 C
X	1	Concentration > 2 moles
	0	Concentration = 2 moles

A warning signal (W = 1) will be generated if

either :   (a) Chemical Rate < 10 m /s

or   (b) Temperature > 87 C and Concentration > 2 moles

or   (c) Chemical rate = 10 m /s and Temperature > 87 C

Draw a logic network and truth table to show all the possible situations when the warning signal could be received

4. A power station has a safety system based on three inputs to a logic network. A warning signal (S = 1) is produced when certain conditions occur based on these 3 inputs:

Input	Binary Value	Plant Status
T	1	Temperature > 120C
	0	Temperature ≤ 120C
P	1	Pressure > 10 bar
	0	Pressure ≤ 10 bar
W	1	Cooling Water > 100 l/hr
	0	Cooling Water ≤ 100 l/hr

A warning signal (S = 1) will be generated if:

Either : (a) Temperature > 120C and Cooling Water <= 100 l/hr

 Or   (b) Temperature <= 120C and (Pressure > 10 bar or Cooling Water < 100 l/hr)

Draw a logic network and truth table to show all the possible situations when the warning signal could be received.

5. Draw a circuit diagram for δ = (xy' + x'y)z
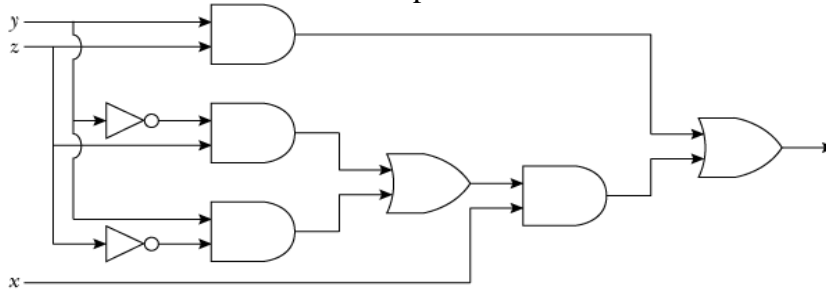6. Device a suitable Boolean expression and truth table for the circuit below:

FIGURE 12.19   A circuit

7. Draw circuits for following Boolean statements.
a. If A AND B are on AND C AND D are on then output is on.
b. If A OR B are on AND C OR D are on then output is on.
c. If A OR B is on then output is off.
d. If B AND C is off OR A is on then output is on.
e. If A is off AND B OR C is on AND D is off then output is on.
f. If A is on AND B AND C are off AND D is on then output is on.
g. If smoke detector (S) is on OR fire alarm (F) is on then sprinkler (W) is on.

8. a. Simplify the following logic equations by using the rules of Boolean algebra.

a. A • C + A • B • C

---

b. $(A + B) \cdot (B + \bar{A})$

c. $A \cdot (\bar{A} + C) + C$

b. For each of the previous questions, create a circuit for the Boolean expression before simplification.

Closed-Circuit Television (CCTV)

- Closed-circuit television is the use of one or more video cameras to produce video signals that are not broadcast, but displayed on a monitor screen. The images may be recorded.
- The camera may be remotely controlled by an operator or by a computer that receives data from sensors signalling an event of interest in a particular area.
- The computer's software could react by tilting and zooming the CCTV camera onto the area protected by the sensor and starting to record the camera's video stream.
- Mostly used in shops to record all transactions, e.g. capturing video of customers. It can be easy to identify shoplifters and thus reducing theft of goods in shops.
- CCTV is now being used even to record street events. This has been triggered by rise in terrorist activities especially in Western countries and the United States.

COMPUTER NETWORKS
Definition of Terms
Network: A connection of computers for them to share data, files and resources like a printer.
Advantages of Networking
- Expensive peripherals like printers and scanners can be shared between users.
- Messages can be sent easily and faster between users whether on WAN or LAN.
- Avoids duplication of information as users can access the same file on the network.
- Network software can be purchased cheaply than buying individual packages for each computer.
- It is possible to access data or programs from any terminal or workstation.
- Data and programs can be stored centrally making it easier to maintain and backup.
- Users can be easily prevented from accessing files not intended for them.
- Allows sharing of files, software and data held in computers.
- Allows emails to be send between users.

Disadvantages of Networking
- Sophisticated equipment is needed, which may be expensive to buy.
- Security of data can be a problem due to hacking.
- Wiring can be expensive both to buy and to install; wiring can be sunk on the ground to avoid trailing cables.
- If a server breaks down, the whole network becomes unusable.
- Networks need experienced network managers, who will be highly paid to keep the network running.

Types of Networks
- Computer networks are grouped into **Local Area Networks (LAN)** and **Wide Area Networks (WAN).**
- However we also have **WLAN (Wireless Local Area Networks), MAN (Metropolitan Area Networks)** and **PAN (Personal Area Networks)**; and these are described below.

1. Local Area Networks (LAN)

This is the connection of computers over a very small geographical area, like in a single room, for user to share files, data, software and hardware like printers. Other LANs can link different departments (e.g. Sales, Accounts, Warehousing, Despatch, etc) within an organisation's complex. A LAN is usually owned by one organisation. However, if an organisation uses internet service within its restricted private Local Area Network, such a network is called an Intranet (private network).

NB: **Intranet** is a private organisation's network that uses internet technologies for the benefits of such an organisation.

Extranet: an extension of the intranet giving authorized outsiders controlled/limited access to the intranet.

Requirements for a LAN Connection

A. Hardware Requirements

1. Host computer / Server: This is the main computer that control and manage other computers on the network.

2. Workstations/Terminals: These are computers that are on the network and are linked to each other. Workstations are computers that can work on their own as standalone computers. Terminal are controlled by the host computer. If the terminal has its own processing and storage capabilities, it is called an **intelligent terminal**. However, if the terminal does not have its own processing and storage facilities and relies on the host computer for it to work, it is called a **dump terminal**.

3. Network cables: These act as pathway for data from one computer to another. Cables can be coaxial, fibre optics, twisted pair, etc.

4. Hub/switch: a device used as a connection point for devices and computers on a Local Area Network. Usually used when connecting computers to a star network.

5. Network cards for each computer/terminal: - a device that identifies computers to the network, where network cables are plugged on the computer

NB: A bridge can also be connected to link a Local Area Network to another network and is **an optional** requirement.

However, some networks are now using wireless technology and these are called **Wireless Local Area Networks (WLAN).** WLAN uses radio signals and therefore no cabling is required.

The diagram below shows the structure of a LAN that can be connected to another network.
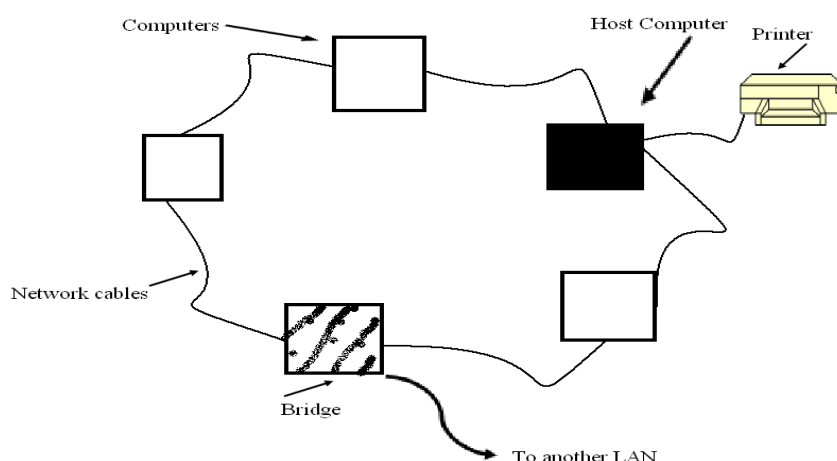
Software Requirements for A LAN Connection

a. Communication software like TCP/IP – Transmission Control Protocol Internet Protocol. A protocol is a set of rules followed by devices when they are communicating.

b. Network operating system: manages the network and network devices

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2. MAN (Metropolitan Area Network)

A network similar to a LAN, but usually extends to a larger geographical area, usually the whole city and is owned by a consortium of users. The network is only accessed by a group of users as defined by the organisation, e.g students of a certain university. It enables users to do researches, share files, libraries, local email and video conferencing.

3. Wide Area Network (WAN)

Refers to the connection of computers over a large geographical area, often over 1 km, e.g. covering the whole district, province or different countries. Internet is also part of WAN. WANs can also be wireless.

Hardware Requirements for a WAN

a. Modem (Modulator Demodulator):- a device that converts analogue data from the telephone line to digital data that can be understood by the computer and vice versa; often for internet connection using a telephone line. They can be used as gateway for connecting LAN to a WAN

b. Communication link: Acts as a transmission media for data, e.g. telephone line, satellite transmission, etc.

c. Network cards for each computer:- a device that identifies computers to the network, where network cables are plugged on the computer

Software Requirements for a WAN

i. Communication Software like TCP/IP – Transmission Control Protocol Internet Protocol.

ii. Web Browser: refers to software used for opening web pages on the internet, for example Microsoft Internet Explorer, Netscape Navigator, Mozilla Firefox, etc. it is used by users to hook to the internet.

iii. Network operating system: manages the network and network devices.

4. PAN (Personal Area Network)

This a very much limited network, usually used by one person. This can also be Wireless Personal Area Network **(WPAN)**, for example connection through Bluetooth. Bluetooth connects different devices, usually over a short distance.

A PAN enables user to transfer files from a laptop to a PDA, camera or Personal Computer.

Network Topology (Configuration)

This refers to the shape/configuration of the network. Common network topologies are Ring, bus, star and mesh network topologies.

1. Ring Network:
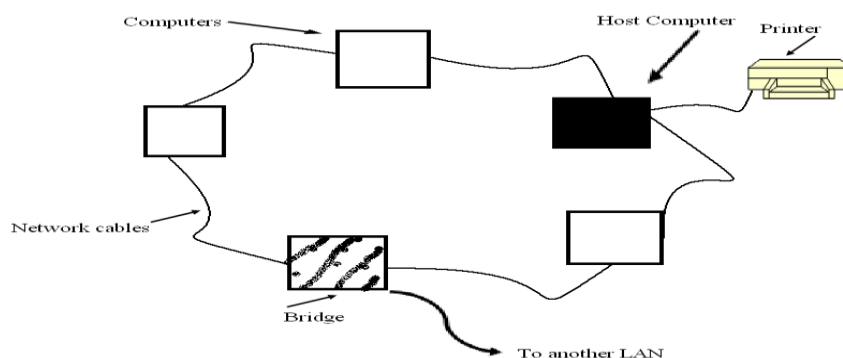
- Computers are connected together to form a circle and uses a token when transferring data.
- Data/information travels in one direction only.
- Information moves around the ring in sequence from its source to its destination.
- As data passes from one computer to another in the ring, each computer removes any data relevant to itself and adds any data it wishes to send.

Advantages of Ring Network
- Data processing is faster as each computer processes its own processor.
- Has very high data transfer rates.
- Uses a token to avoid data collision or loss
- it is possible to create large networks using this topology
- If one computer breaks down, others will remain working as they have their own processors and storage facilities.
- Performs better than star network when traffic is very heavy.

Disadvantages of Ring Network
- If one computer breaks down, the whole network is disrupted.
- a faulty connection between two stations can cause network failure
- Its requirements are expensive, that is buying several computers with processors and storage facilities.
- It is difficult to link the computers together.
- Difficult to add another computer without disrupting the networking.
- Only the computer with the token is allowed to send data at a given time. One may not send data when another node (computer) is still sending its own data.
- System is less secure as token together with data has to pass through other nodes that do not concern it.
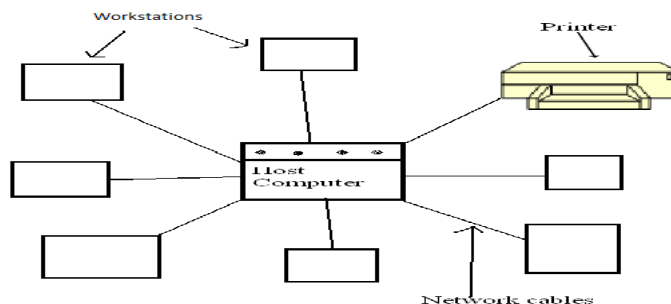

2. Star Network:

Computers form a star shape with host computer at the centre.
The Server (host computer) manages all other computers/terminals on the network.
If the terminals are not intelligent, they have to rely on the host computer for everything.
This network is as shown below:

Advantages of Star Network
- If one terminal breaks down, the network is not disrupted.
- It is cheap in terms of requirements since only the host computer can have a processor and storage facility.
- It is very easy to install.
- Management of data is easier as this is done centrally.
- It is very fast to process data.
- Easier to add new workstation without disrupting the network.
- No problem of collision of data since each terminal has its own cable to the host computer.
- Gives consistent performance even when the network is heavily utilised.
- More secure than other network topologies
- it is easier to identify faults using this type of topology

- It is easy to expand this type of network
- If one terminal breaks down, others will remain working.

Disadvantages of a Star Network
- If the host computer breaks down, the whole network will be disrupted.
- If the host computer is down, all the terminals will not work as they depend on the host for processing and storage.
- It requires a lot of cabling, which might be expensive.
- Can be slower if overloaded

3. Mesh Network
- A network in which each computer serves as a relay point for directly sending information to any other computer on the network.
- No central device oversees a mesh network, and no set route is used to pass data back and forth between computers.
- Thus, if any one computer is damaged or temporarily unavailable, information is dynamically rerouted to other computers—a process known as *self-healing*
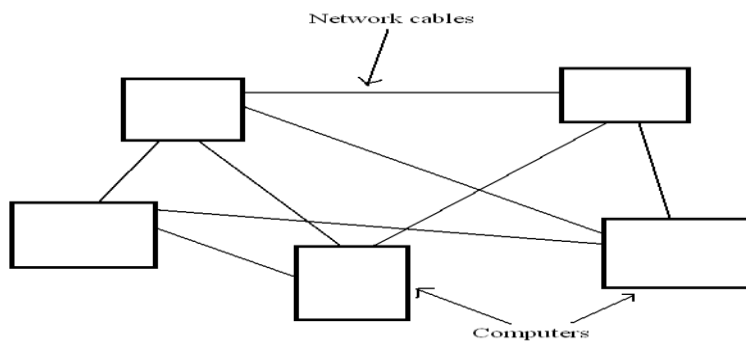

Advantages of Mesh Network
- If one computer breaks down, others will remain functional.
- If one computer breaks down, the network is not disturbed.
- Computers have their own storage and processing capabilities.

Disadvantages of Mesh Network
- Expensive to buy computers with their storage and processing facilities.
- Too much cabling is involved, which may be expensive.

4. Bus (Linear/Multi-drop) Network:
Computers are connected together through one main cable and all computers all signals transmitted by any computer connected to the network
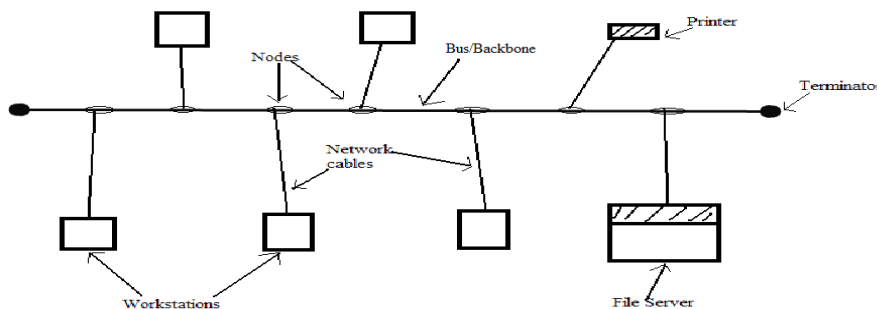
Definition of Terms
(a) **Bus/Backbone**: the dedicated and main cable that connects all workstations and other computer devices like printers.
(b) **Nodes**: these are connection points for workstations and the bus.

(c) **Terminator**: devices that prevent data in the bus from bouncing back, causing noise and prevents data from getting lost.

Advantages of Bus network
- If one workstation breaks down, others will remain functional.
- If one workstation breaks down, the network remains working.
- All computers have processing and storage capabilities.
- It is cheap to install due to less cabling.
- Easy to add workstation without disrupting the network.
- Requires less cabling than a *star* network.
- Less expensive network than the other systems

Disadvantages of Bus Network
- Computers cannot send data at the same time nor while there is data being transferred in the bus.
- Can cause collision of data during transmission.
- It is slow in transferring data.
- Its requirements are expensive, that is computers with their own processors and storage facilities.
- The system will be down if the main cable (bus) is disrupted at any point.
- Less secure.
- Performance worsens as new stations added

NB: Point – to-Point Connection: Point-to-point topology is the simplest connection, consisting of two connected computers.

Peer-to-Peer Networks
- A peer-to-peer network is the one which does not have a server.
- All computers have an equal status.
- Each workstation can use resources from any other workstation and communicate directly with every other node on the network without using a server.
- Used when users do their own work and share data.
- Storage facilities are distributed throughout the network
- It can be difficult to remember which files are located in which computer
- Each computer has its own software
- Less expensive
- Less difficult to administer
- Appropriate for small businesses
- Security is not centralised
- Backup is a responsibility of individual computer user
- Cheap to use
- No need for special network operating system

Diagrams:
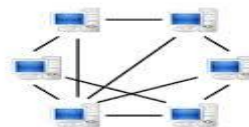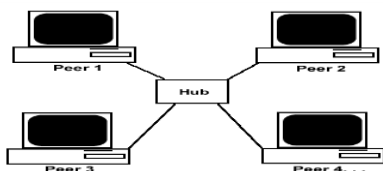
Server based Networks
- These are networks with a server which stores data or monitors and control other computers on the network. This could be a file server, print server, etc.

Server-based
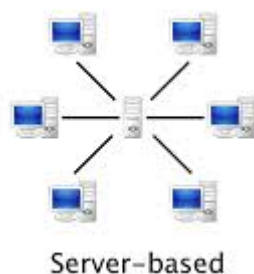
Network Protocols

A protocol is a set of rules that governs how communication between two devices will occur. Such devices might be computers themselves, between modems.

A network communication protocol: a standard method for transmitting data from one computer to another across a network. Some of the protocols that we are going to look at are:

i. **TCP/IP (Transmission Control Protocol Internet Protocol)**

TCP: It ensures that data is transmitted accurately

IP: It ensures that data is transmitted to its correct address (IP address). Every device on the internet has its IP address. It also ensures that packets are rearranged to the original message on arrival of their destination.

ii. **HTTP (HyperText Transfer Protocol)**

This is a protocol that defines the process of identifying, requesting and transferring multimedia web pages over the internet. It is used for transferring data across the internet, usually between servers and computers on the internet. It is based on the client –server relationship. It uses TCP/IP to transmit data and messages

iii. **FTP (File Transfer Protocol)**

it is a protocol used to transfer data from one computer to another. It is often used to download software from the internet, and it uses the TCP/IP protocol in doing this. However, FTP has no security to data as the data is not encrypted prior to its transmission.

iv. **TELNET**

This is a network protocol that allows a computer user to gain access to another computer and use its software and data, usually on a LAN and on the Internet. It allows users to access data stored on servers from their terminals. Telnet allows computers to connect to each other and allows sharing of data and files. Telnet has security problems especially on the internet.

v. **VoIP (Voice Over Internet Protocol)**

It is a method of using the internet to make ordinary voice telephone calls. Thus it is a way of having phone conversations using the internet as a way of communication. By VoIP, international and long distance calls are of the same price as local calls and sometimes are for free. However, the system does not offer emergency calls. An example of VoIP is Skype.

SYSTEMS ANALYSIS AND DESIGN

Systems Analysis is the detailed investigating the current system to determine is problems, requirements and the best way of solving the problems.

System: A groups of elements working together to achieve a common goal. Systems are of two types:

Physical system: refers to tangible systems like schools, firm, shop, etc

Conceptual systems: these exist in mind or paper and cannot be touched. They just represent a physical system.

This chapter is concerned with the development and maintenance of system like stock control, patient monitoring, banking and payroll which are part of physical systems.

The systems analyst

This is a person who identifies problems of the existing system and recommends the best solution to such a problem. The duties of a systems analyst are:

- Identifies the problems of the current system.
- Liaises with system users and determine their requirements.
- Finds out facts important to the design of the new system.
- Determines the human and computer procedures that will make up the system.
- Participates in the process of system implementation.

By performing such duties the systems analyst acts as:

i. **A consultant**: can be called or hired to identify problems in a system

ii. **A supporting expert**: draws together professional expertise concerning computer hardware and software and their uses in business.

iii. **An agent of change**: bring new ideas into the organisation

Qualities of a systems analyst

- Must have good oral and written communication skills for all managerial levels of an organisation.
- Must be able to work as a team.
- Must be well educated, with at least a degree.
- Must be well experienced in computers and at top managerial levels.
- Must have good managerial skills.
- Must be a problem solver and see problems as challenges.
- Must be self-motivated. Must be well disciplined.
- Must be able to work under pressure and meet deadlines.

Initiation (Origination) Of Systems Analysis

Changes to a system can be triggered by many factors, some of which are:

i. System users: they may be dissatisfied with the current system since they are the ones who operate it. They will the sent requests to have a new system or some modification to the existing one.

ii. Top management: they may issue directives in order to meet new organisational objectives. It can also be due to change in management (new manager), new requirements, etc.

iii. The need for improved operating efficiency: Errors in the existing systems may be intolerable, especially to customers.

iv. Changes in technology: new hardware and software may force organisations to change their ways of operation.

v. Change of government policies: new government laws and policies can force organisations to change their systems

vi. The user can change his mind

Systems Development Life Cycle (SDLC)

This refers to the stages through which a system develops from 'birth' to 'death', i.e. from the moment the system is incepted until it is modified or replaced with a new one.

Can also be referred to as the Waterfall Model

The stages, in their order, include:

- Problem identification,
- Fact Finding
- feasibility study,
- analysis,
- design,
- Development and testing
- Documentation and user training
- implementation,
- Evaluation/review/maintenance.

Below is a diagram that indicates the SDLC stages
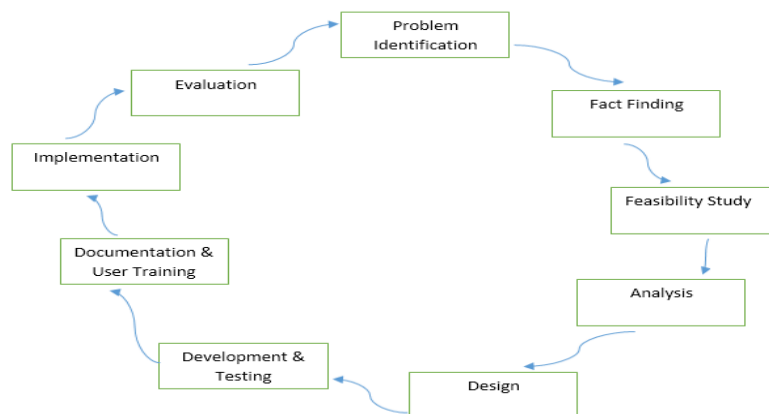
Below is an explanation of each of the stages listed above:

1. Problem identification/Recognition/Definition/Realisation:

This is where the problems of the current system are stated.

These might have been realised by system users or by managers. The system might be producing wrong results.

This includes the general statement of the problems being experienced by the system.

2. Fact Finding/Data Collection/Investigation

This is the stage whereby the analyst collects data from users, management and the stakeholders, about the current system. Each data collection procedure is appropriate for a given situation, not in all cases. A number of data collection techniques are employed, including the following: Questionnaire, interview, Record inspection and Observation.

Some automatic data collection procedures may be used also.

Data Collection Procedures

Terms used in data gathering include:

a. Interviewer: The person who asks questions in order to solicit information

b. Interviewee (respondent): interviewee is a person who is asked questions and is expected to give information to the interviewer.

c. Population: The average number of people in an area where a research is to be carried out.

d. Sample: Fraction of the population who actually take part in the research.

i. Interview:

This refers to the face-to-face communication between two or more people in order to obtain information. Interviews can also be done over the phone but the most common ones are face to face. Interviews are done when you want to collect information from a very small population sample.

Advantages of Interviews

- The researcher can ask for clarification on some points that may not be clear.
- Encourages good rapport between the researcher and the respondent.
- Non-verbal gestures like facial expressions can help the researcher to determine if the respondent is telling the truth.
- Information can be collected even from the illiterate since the respondent's language could be used.
- First-hand information is collected.
- The researcher can probe to get more information.

Disadvantages of Interviews

- It is impossible to remain anonymous on the part of the interviewee.
- It is expensive since the researcher has to travel to the interview venue.
- It is time consuming as more time is spent travelling and carrying out the interview.
- Good interview techniques are required as failure may lead to disappointments.
- Biased information can be given since the respondent may not tell the truth.

ii. Record/Document inspection:

- A fact finding method which involves scrutinising system documents in order to solicit information.

Record inspection has the following advantages:

- Accurate information is collected from system records.
- First-hand information is obtained

Disadvantages of record inspection

- It is time consuming to go through all system records.
- Manual files can be tiresome to go through and some of the data may be illegible.
- Confidential files are not given to the researcher

iii. Questionnaire:

A document with carefully crafted questions to be answered by the respondent by filling on the spaces provided. Questionnaires are used when collecting information from a widely spaced population sample and when collecting information from many people. A questionnaire contains open-ended and closed questions. Open-ended questions are gap filling questions which require the respondent to express his or her own view. Closed questions are guided questions where the respondent just chooses Yes or No, True or False, or by just putting a tick on given options. Questionnaires can be distributed personally or by post.

Advantages of questionnaires

- Questions are very simple and faster to answer.
- It saves time as questionnaires can be distributes and then collected later.
- Respondents can fill questionnaires at their own pace.
- Give guarantees confidential of information, thereby encouraging respondents to give accurate information.
- They are cheap to use when collecting data from a very large sample

Disadvantages of questionnaires

- Some questions are left blank.

- Some questionnaires may not be returned at all.
- Biased information can be collected as people may lie.
- Respondents usually do not fill the correct information.
- It is difficult to analyse information collect using questionnaires.
- They are expensive to use if the postal system is used.
- Abusive information can be filled by respondents.
- It is difficult to prepare a good questionnaire

iv. Observations:

It is a fact finding method that involves viewing the actual system in operation by the researcher. The researcher can even take part in operating the system. It is used when the researcher wants to see for himself how the system operates.

Advantages of observations

- First-hand information is collected.
- Accurate information can be obtained.
- Areas of interest can be observed.
- The researcher can take part in operating the system thereby getting insight on how the system operates.
- the analyst obtains reliable data
- it is possible to see exactly what is being done

Disadvantages of observations

- People work differently if they feel that they are being observed, therefore inaccurate information can be collected.
- The researcher may not understand some of the activities being observed.
- It is time consuming to collect the required information.
- The researcher may interrupt some of the activities being done.
- if workers perform tasks that violate standard procedures, they may not do this when being watched!!

3. Feasibility Study:

It involves an evaluation of proposals to determine if it possible to construct a new system or just modification of the existing one. Feasibility can be measured by making the following considerations:

Economic feasibility: determining whether the benefits of the new system will out-weigh the estimated cost involved in developing, purchasing, assembling requirements, installing and maintenance of the new system. The cost-benefits analysis is carried out. Benefits can be tangible and quantifiable, e.g. profits in terms of monetary values, fewer processing errors, increased production, increased response time, etc. Other benefits are intangible, e.g. improved customer goodwill, employee moral, job satisfaction, better service to the community, etc.

Technical feasibility: determines if the organisation can obtain software, equipment and personnel to develop, install and operate the system and even to maintain it.

Social feasibility: a measure of the system's acceptance by the general public; if it will meet the norms and values of the society.

Legal feasibility: This is determining if the system can conform to the laws and statutes of the country. This is done by considering government legislation, e.g. Data processing system must comply with the local Data Protection Acts

Operational feasibility: determines whether the current work practices and procedures are adequate to support the system, e.g. effects on social lives of those affected by the system, can it work well with existing hardware, etc

Operational feasibility assessment focuses on the degree to which the proposed system fits in with the existing business environment and objectives with regard to development schedule, delivery date, corporate culture, and existing business processes

After carrying out the feasibility study, a feasibility study report must be produced and it contains the following information:
- A brief description of the business.
- Advantages and problems of the existing system.
- Objectives of the new system.
- Evaluation of the alternative solutions.
- Development timetable.
- Management summary.
- Terms of reference.
- Proposed solution.

4. Analysis stage:
This is the in-depth study of the system to determine how data flows within the system. Analysis tools used includes:
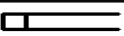- Decision trees
- Decision tables

It involves use of flowcharts, data flow diagrams, structure diagrams, decision trees, and others, to describe the operations of the system in detail. The analysis stage determines whether computerisation will take place or not. The analysis stage also specifies the hardware and software requirements of the new/proposed system, the advantages and disadvantages of the proposed solution, etc.
Analysis stage also involves identification of the following:
- Interviewing workers and management
- Alternative solutions: other solutions, not considering the chosen one
- Specification requirements: (hardware requirements, software requirements), personnel requirements, etc
- Carrying out the Cost-benefit analysis: weighing out costs of developing the new system versus the benefits that will be realised.
- Determining how data flows within the system using DFDs
- Studying current systems inputs
- Studying current system outputs
- Decides on what the project/system needs to achieve

Dataflow Diagrams
These are diagrams that show how data moves between external sources, through processes and data stores of a particular system. Dataflow diagrams use the following symbols:

Symbol	Explanation
Process Symbol	- Indicates where some form of processing occur
File Storage	- Shows data storage in a file
Arrow	-Shows directional flow of data
Entity	- Shows an external source or destination of data for the system
Predefined Process	- Shows a predefined process, like sorting of data.

5. Design Stage:
This stage is concerned with the design of the new computer based solution as specified by the analysis stage. Design stage involves:

Input Design: includes designing of data entry forms, input methods (e.g. by filling forms, use of barcodes, etc) and the user interface.

Output Design: Includes design of reports, data output formats, screen displays and other printed documents like receipts, etc.

File design: Involves designing tables/files, records and validation rules. It also involves determining how data is to be stored and accessed, the media to be used for storage and the mode of file organisation. Fields in each files can be designed, their length and data type, e.g.

>**File Name**: Student File
>**Storage Location**: Hard Disk
>**Mode of Access**: Direct/Random

File Structure:

Field name	Data type	Length	Example
Surname	Alphabetic	20	Kapondeni
First name	Alphabetic	20	Tungamirai
Date of birth	Date	8	07/02/78
Class	Text	2	3A
Student number	String	7	0098/99

It also involves specifying how data is to be sorted and updated.

Program Design: Involves design of systems flowcharts, structure diagrams, dataflow diagrams, algorithms, etc. **Selection of appropriate hardware**: Specify the input hardware, output hardware, processing hardware and speed, storage media, RAM size, etc.
Selection of appropriate software: specifying the type of operating system, programming language or database package and other application packages to be used.
Design of test plan and strategy, Design of the user manual, Design of the technical documentation
In general, design stage involves the following:
- ✓ design the data capture forms/input forms
- ✓ design the screen layouts
- ✓ design output forms and reports
- ✓ produce systems flowcharts and/or pseudocode
- ✓ select/design any validation rules that need to be used
- ✓ design a testing strategy/plan
- ✓ file structures/tables need to be designed/agreed
- ✓ select/design the hardware requirements for the new system
- ✓ select/design the software requirements
- ✓ produce any algorithms or program flowcharts
- ✓ select the most appropriate data verification method(s)
- ✓ interface design(Command-line, GUI, form-based, menu-driven, etc

6. Development and Testing

The computer environment is prepared, the programs to be written are done and they are tested to determine if the run as expected.

Computer environment being prepared: electrical wires, network cables are installed, furniture, air conditioning are in place. The computers are installed and tested.

It also involves the construction and assembling of the technical components that are needed for the new system to operate. This includes preparation of the computer room environment, coding of the computer program using a specific programming language, testing of the coded program,

Testing strategies
- **standard (normal) data testing**: testing of data within the given range (should be accepted)
- **abnormal data testing**: testing of data outside the given range (should be rejected). It gives an error message when entered into the computer system.
- **extreme (boundary) data testing**: testing of the minimum and maximum values in the given range (should be accepted)

7. Documentation and User Training
Documentation refers to the careful and disciplined recording of information on the development, operation and maintenance of a system. Documentation is in two main types: user documentation and technical documentation

(a) User Documentation: It is a manual that guides system users on how to load, operate, navigate and exit a program (system). User documentation contains the following:
- ✓ System/program name.
- ✓ Storage location.
- ✓ System password.
- ✓ Instruction on how to install the program.
- ✓ Instruction on how to operate the system: e.g.
  - How to quit the program
  - how to load/run the software
  - how to save files
  - how to do print outs
  - how to sort data
  - how to do a search
  - how to add, delete or amend records
  - print layouts (output)
  - screen layouts (input)
  - the purpose of the system/program/software package
  - error handling/meaning of errors
  - troubleshooting guide/help lines/FAQs
  - how to log in/log out

(b) Technical Documentation: This is a manual for programmers which aid them in modifying the system and in correcting program errors. The following are found in technical documentation:
- ✓ Algorithms of the program,
- ✓ Program testing procedures and test data,
- ✓ Sample of expected system results,
- ✓ Program structure showing modules and their relationships,
- ✓ System flowcharts,
- ✓ Programming language used,
- ✓ Program code,
- ✓ program listings,
- ✓ File structures.
- ✓ Validation rules

✓ Output formats
✓ Bugs in the system
✓ Hardware requirements
✓ Software requirements

User Training:

Once a new system is put in place, existing employees are trained on how to operate the new system, otherwise new employees are recruited. Users are trained on how to enter data, search records, edit fields, produce reports, handling errors, etc.

User training can be in the following forms:

i. On the job training: Users are trained at their organisation by hired trainers. This has the following advantages:

✓ Learners practice with actual equipment and the environment of the job.
✓ Learners can engage in productive practices while on training.
✓ This is cheaper for the organisation.
✓ Enough practice (experience) is gained on how to operate the system.
✓ Production does not stop

Disadvantages of on the job training

✓ Distractions occur in a noisy office.
✓ Instructional methods are often poor.
✓ The need to keep up output may lead to hasty teaching
✓ Mistakes by learners can be disastrous for the system

ii. Classroom training: Users are send to other colleges and institutions which offer courses on the subject matter. This could be expensive to organisations since employees take study leave while being paid at the same time. Employees can also be trained on aspects that they will not apply when they finish the course. The gap between what is learnt and what is needed at the job may be too wide.

Considerations when training users:

1. All staff need training that is relevant to their work using the computers. However, others may find it difficult to learn the new system and may resist.
2. Age problem of trainees-older workers takes long to conceptualise concepts
3. Reluctance of employees to learn (use new system)
4. Computer based system means training on the computer
5. Regular updates means new training each time an upgrade is made
6. The type of training should be chosen carefully as it is important
7. Course type with trainer
   o It may restrict learning times
   o Can be intimidating to other employees
   o Difficult to satisfy all trainees' demands
   o Gives human contact

8. Implementation/ Conversion (Installation/Changeover)

This also involves putting the new computer system into operation, that is, changing from the old system to the new one. It involves file conversion, which is the changing of old data files into the current format. Different changeover methods can be used, and these include:

a. Parallel Run: This involves using of both the old and new system concurrently until the new system proves to be efficient. It involves operating the new and old systems simultaneously until management is confident that the new system will perform

satisfactorily. Other workers will be using the old system while others use the old system but doing the same type of job.

Advantages of parallel run
- ✓ Results for both systems are compared for accuracy and consistency.
- ✓ If the new system develops problems, it will be easier to revert to the old one.
- ✓ There is enough time given to determine if the new system produces expected results.
- ✓ Employees have enough time to familiarise with the new system.

Disadvantages of Parallel run
- ✓ Running two systems at the same time is very expensive.
- ✓ Running two systems simultaneously is demanding to employees.
- ✓ It may be difficult to reach a decision when comparing the two systems.
- ✓ There is duplication of tasks which in turn stresses employees

ii. Abrupt (Direct) changeover: Involves stopping using the old system on a certain day and the new system takes over on the next morning. This is suitable for control systems like in chemical plants and for traffic lights.

Advantages of Direct Changeover
- ✓ Reduces cost as of running two systems at the same time.
- ✓ Faster and more efficient to implement.
- ✓ There is minimum duplication of tasks.
- ✓ Enough resources can be allocated to make sure that the new system operates successfully.

Disadvantages of Direct Changeover
- ✓ It will be difficult to revert to the old system if the new system fails.

iii. Phased / Partial conversion: This is whereby the old system is gradually removed while the new system is gradually moved in at the same time. This can be done by computerising only one department in an organisation this month, then the next department in two months' time, and so on until the whole system is computerised.

Advantages of phased conversion
- ✓ Avoids the risk of system failure.
- ✓ Saves costs since the new system is applied in phases.
- ✓ It could be easier to revert to the old system if the new system fails since only one department will be affected.

Disadvantages of phased conversion
- ✓ It could be very expensive since the organisation will be running two systems but in different departments.

iv. Pilot conversion: This is whereby a program is tested in one organisation (or department), and is applied to the whole organisation if it passes the pilot stage. It serves as a model for other departments. A pilot program can then be applied in phases, directly or using the parallel run method.

NB: Implementation also involves the following activities:
- Acquisition of the necessary equipment / hardware and software
- Identifying and specifying modules to be used
- Identifying the main data structures within the program
- Identifying the main modules / algorithms to be used
- Installation of hardware
- Software installation
- Designing office layouts
- Cabling/trunking

- User training, etc

9. Maintenance/review/evaluation Stage:

This stage is concerned with making upgrades and repairs to an already existing system. Certain sections of the system will be modified with time.

Maintenance can be to **Perfect** the system, to **Correct** some errors or to make it **adapt** to changing needs, e.g. change in government laws. Maintenance involves the following:

- update hardware as new items come on the market or the company changes in any way which requires new devices to be added/updated
- update software if necessary if company structure changes or legislation is introduced which affects how the company operates

Evaluation involves the following:

- compare final solution with the original requirement
- identify any limitations in the system
- identify any necessary improvements that need to be made
- evaluate the user's responses to using the new system
- compare test results from new system with results from the old system
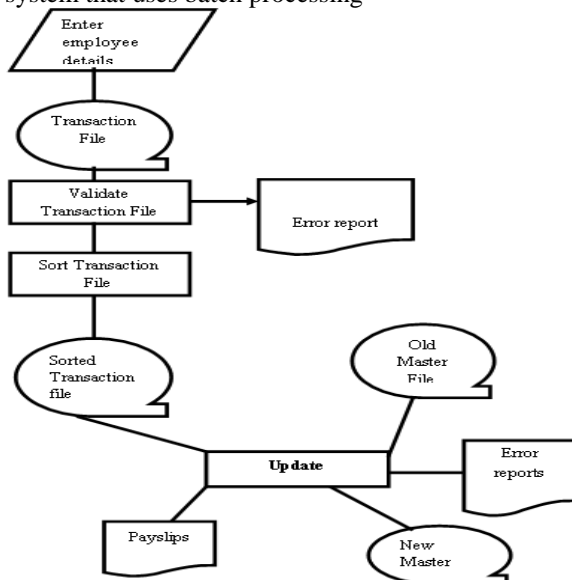- compare performance of new system with performance of old system

Assessing the effectiveness of the new system:

- compare final solution with original requirements
- identify any limitations in the system
- identify any necessary improvements that need to be made
- evaluate user responses to using the new system
- compare test results from new system with results from old system
- compare performance of new system with performance of old system
- effectiveness of the hardware
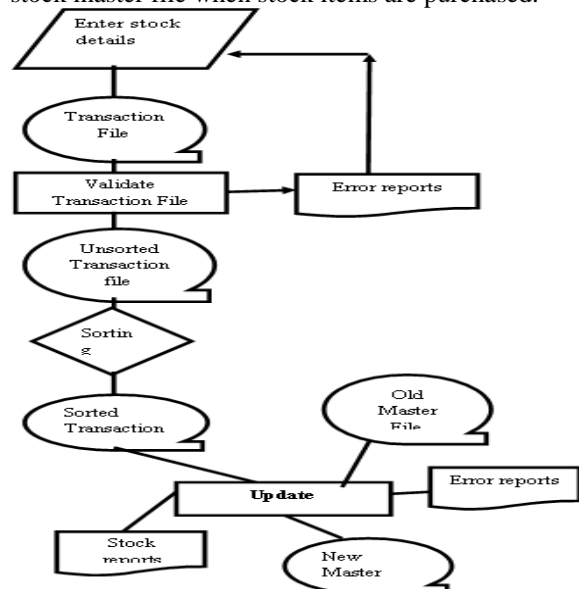- effectiveness of the software

(a) System Flowcharts

An example of a systems flows cart is as follows:

Below is a systems flowchart for a payroll processing system that uses batch processing	Below is a systems flowchart that is used to update a stock master file when stock items are purchased.
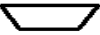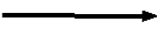
A systems flowchart is a diagram used to show how all the components in a system link together (e.g. input, storage, output, processing, etc.). They are very different to normal flowcharts since they don't go into detail of how something is actually done – they are a

general overview. It shows the overview of the system, tasks carried out by the system, whether manual or computer, devices, output media and files used, etc.

Common symbols for designing systems flowcharts are as follows:

Symbol	Explanation
Process Symbol	- Indicates where some form of processing occur
Document	- Indicates a printed document
Display	- Indicates screen display
Manual input	- Indicates a manual input method, for example through keyboard
Manual Operation	- Indicates where manual operations occur
Offline storage	- Indicates where data is stored offline
Magnetic Tape	- Indicates file storage on a magnetic tape
Disk Storage	- Shows data storage on a magnetic disk, like hard disk.
Arrow	-Shows directional flow of data
Sorting	- Indicates a stage where data is being sorted
Punched tape	- Indicates storage on a punched tape
Internal Storage	- Indicates data storage on internal storage, e.g. RAM or ROM
Multi-document	- Indicates where a number of documents are involved
Card	- Shows data on card
Direct Storage	- Shows data storage on any direct storage device
Communication line	- Indicates communication line like telephone, wireless communications, etc
Data	- Indicates where data is entered.

*__NB__: Meanings of these symbols are not universal and mean a different thing to others. Some symbols are borrowed from program flowcharts.

Review Questions
1. (a) A systems analyst was brought in to computerise a paper -based car sales system. What methods could be used to gather data about the existing system? Give reasons for your choice.
   (b) What would need to be done before the new computerised system become 'Live'?
   (c) Why would PILOT and PARALLEL change over methods be suitable in this application?
2. A program is written to input daily temperatures. Name three types of test data that could be used. Give examples of each type of test data which could be used and discuss the outputs you would expect to get.
3. Name **five** tasks that would be carried out at the DESIGN stage in systems analysis.
4. Name **four** methods used to change over from a manual system to a new computerised system. Discuss the relative advantages and disadvantages of these four methods.
5. Describe how the effectiveness of a new computer system can be assessed

DATA CAPTURE / COLLECTION

Data capturing can be either automatic or manual.

Manual methods are slow in entering data and are also prone to errors, e.g. typing 2.3 instead of 3.2. Manual data capturing techniques includes the following:

- keyboards/keypads to type in data
- touch screens to select data/options

Automatic data capturing techniques are more accurate and faster but are more expensive and involves use of the following:

(a) **Data logging**: this technique involves collecting data automatically using sensors; mostly used when doing scientific experiments or monitoring a control system

(b) **Barcode readers**: these take data from printed barcodes and allow automatic stock control in, for example, supermarkets.

(c) **Radio Frequency Identification (RFID):** this method involves using small electronic devices containing a microchip and antenna; they work in a similar way to bar codes but can be read from a distance of 5 metres; often used to track livestock, vehicles, library books and goods sold in shops.

(d) **Biometrics:** this involves obtaining data and identifying characteristics automatically in security systems e.g. use of finger prints, palm prints, facial images and iris prints

(e) **Magnetic Strips:** these contain information/data stored on magnetic material often on the back of a credit/debit card; the information is automatically read by swiping the magnetic stripe past a reading head (reading device).

(f) Optical character recognition (OCR): information on paper is automatically read by a scanner and is then analysed/processed by OCR software and stored in an electronic format.

(g) Voice recognition: these systems recognise spoken words e.g. for disabled people who can't use keyboards where they speak commands instead of having to type

(h) Smart cards: these contain embedded microchips and receive power from the card readers; the microchip is made up of RAM, ROM and 16-bit processor and the stored data is automatically read by the card reader; used in credit cards, security cards, loyalty cards, etc.

(i) Optical Mark Recognition (OMR): OMR technology scans a printed form and reads pre-defined positions (where specific fields have been filled in e.g. ●━● or ▪); the system records where marks have been made so can automatically determine responses to, for example, a questionnaire.

Data Entry Errors

Data can be entered incorrectly into the computer and this can have the following effects:

- A company can be prosecuted under the **Data Protection Act** if incorrect information causes a person or organisation some loss.
- Wrong decisions can be made by managers due to wrong information given.
- Customers may be angry if they are sent wrong bills.

Types of Errors

1. Transcription Errors: These are mistakes due to misreading or mistyping of data, e.g., confusing the number 5 with the letter S, 0 (zero) instead of the letter O, etc. This can also be caused by bad handwriting.

2. Transposition Errors: These are mistakes caused by swapping 2 letters or digits, e.g. typing 'ot' instead of 'to', 5721 instead of 7521. Transposition errors occur mostly when typing at very high speeds.

3. Error of Omission: Some information might have been skipped from being entered.

Avoiding Data Entry Errors

The following procedures can be used to avoid / reduce data entry errors:

1. Verification: Involves checking whether what has been entered into the computer is similar to what is on the input document. Also done data is copied from one medium to another, e.g. from paper to disk. Verification is done manually by the user of the computer. Verification is carried out to determine errors that cannot be detected by the computer.

NB:-Verification can also be used to determine if data has been correctly transferred from one place to other (e.g. between devices or on a network).

Verification can be done in the following forms:

(a) Double entry:

- In this method, data is entered twice (using two different people); the data is only accepted if both versions are similar.
- Double entry is often used to verify passwords by asking them to be typed in again by the same person twice.

(b) Visual Checking

- This is checking for errors by comparing entered data with the original document *(NOTE: this is **not** the same as proof reading!!)*. If the entered data is similar with the source document, then it has been entered correctly.

2. **Validation**: A process done by the computer to detect if data entered is valid, correct, complete, sensible and reasonable. For instance the height of a person entered as 12 metres is incorrect, is not sensible, neither is it reasonable, and therefore the computer should reject this. Validation is a process of checking if data satisfies certain criteria when input i.e. falls within accepted boundaries. Validation is done by the computer.

Types of Validation Checks on Data

(a) Character type check: A validation check for detecting if the correct characters have been entered, for example can detect and reject alphabetic letters where numbers are needed. The computer should also reject if a digit is entered where a name is needed, e.g. John5 is wrong since there is a wrong character in the name, i.e., 5.

(b) Range Checks: Are validation checks performed on data to make sure they lie in a specified range. For example, you are required to enter a number between 5 and 20, and you enter 51, the computer should automatically reject this since it lies outside the required range.

(c) Limit Check: this is similar to a range check except only ONE of the limits (boundaries) is checked e.g. input data must be > 10.

(d) Presence checks: check that data is actually present and not missed out e.g. in Student form, somebody's Student Surname may been left out yet it is a required field name. The computer does not allow the user to continue until an entry has been made in a required field name.

(e) Length checks: These are validation checks used to determine if data entered is of the required number of characters. For example, if a student number has 5 digits, the computer should reject if a number with 4 or less digits or even more digits is entered.

(f) Format Check: this checks that data is in a specified format (template) e.g. date should be in the form dd/mm/yyyy.

(g) Consistence (Cross Field) Check: this checks if fields correspond with the other, e.g. if one enters 'MR' on **Title** field, the **Sex** field must contain '**Male'** or '**M**'. If one enters the **title** as **Mr** and then on **sex** enters **Female**, there is no correspondence on the two fields and therefore the computer must reject this.

(h) Spell Checkers: These are validation checks that determine if accurate text has been entered especially in word processing. Spell checkers use custom dictionaries to check

spelling mistakes in documents. If a word is typed in, it is checked if it is in the custom dictionary, if not, it is treated as an error. Spell checkers cannot be used in case of names of people, places, computer jargon, new slang words, etc.

(i) Data Type check: This is used to check if data entered is of the correct data type. For example, **Quantity of Items** bought is an **integer** data type, therefore it must reject fractions. Thus the correct data type is considered in this situation. Data types includes Boolean, integers, char, etc.

(j) Check Digits: A check digit is an extra digit appended to the right -end of an original number for error checking purposes and is calculated from the original block of data using modulus 11.

*NB: - Check digits are used where data is entered automatically as in using barcode readers and are important for checking for transposition errors (swapped digits)

Calculating Check Digits

Using the Modulus 11 method: Suppose a product number has been entered as: **151211323**; the following procedures will be used to calculate its check digit.

We have 9 digits. Working from the right, the first digit is multiplied by 2, second number by 3, third number by 4 and so on. We start at 2 because position 1 is for the check digit. The results are added together, e.g.

$(1x10) + (5x9) + (1x8) + (2x7) + (1x6) + (1x5) + (3x4) + (2x3) + (3x2) = 112$

The total (112) is divided by 11 and the remainder is noted; e.g., 112 divided by 11 = 10 remainder 2.

The remainder is subtracted from 11 to give the check digit: $11 – 2 = \underline{\mathbf{9}}$

9 becomes the check digit. Therefore the number will be transmitted as **1512113239**

*NB: -

(1) If the check digit found is **10,** an **X** is used as the check digit**.**

(2) If, upon dividing the total by **11** and the remainder is **0,** then **0** is the check digit. This is obtained as, 11-0=11. Divide 11 by 11 and take the remainder, which is 1 remainder 0, thus 0 becomes the check digit.

(3) Check digits are used to detect where digits have been **swapped**

NB: thus the procedure of calculating check digits is summarised as follows:

- Allocate weights for digits from right going to the left, starting as 2.
- Multiply each digit with its weight and add them.
- Divide the total by its modulus (11 in our case) and get the remainder.
- Subtract the remainder from the modulus (11)
- The result will be the check digit.
- However, some authors go further by saying that, divide the answer (obtained after subtracting from 11) by its modulus (11) and take the remainder. The remainder is the check digit.

Proving whether the given check digit is correct or not.

This is done using two methods, which are:

(1). Remove the given check digit, calculate your own check digit. If they are similar, then the check digit is correct. If they are not similar, then the given check digit is wrong.

(2) Re-calculate without removing the given check digit using the example given below:

Example:

The ISBN to check is given as with X as the check digit: 0 - 1 3 1 5 - 2 4 4 7 – X

Remember X means 10, so 10 is the check digit in the example above.

Here, the check digit is on position 1. So the numbers and their positions is as follows:

Position	10	9	8	7	6	5	4	3	2	1
Digit	0	1	3	1	5	2	4	4	7	X

Multiply each digit with its position and add the results, thus giving:

(10x0)+(9x1)+(8x3)+(7x1)+(6x5)+(5x2)+(4x4)+(3x4)+(2x7)+(1x10) = **132**

Divide 132 by modulus (11) and get the remainder. This gives us 12 remainder 0.

Therefore the check digit is correct.

NB: If the remainder obtained is 0, then the check digit is correct, if not, then the check digit is wrong.

Differences between verification and validation

Verification	Validation
Check whether data entered in the computer is similar to that on input document.	Checks for correctness, completeness, sensibleness of data.
Done well after data has been entered into the computer.	Done during data entry.
It is a manual process /done by the user.	It is an automatic process/done by the computer.

Questions

1. Describe 4 methods of automatic data capture, giving an application of each method
2. A record contains the following fields:
   - Title (Mr/Mrs/Miss) and Sex (Male or Female)
   - Date of birth (written in the form dd/mm/yyyy)
   - Pay Number (which is made up of 8 digits)
   - Telephone Number
   - Pay

   Give a different validation check for each of the above fields and explain why it is used.
3. (a) Which of the following numbers have the correct check digit?
      (i) 0 – 5 5 5 – 2 1 6 2 2 – 5
      (ii) 0 – 1 2 1 – 9 0 0 2 1 – X
   (b) Calculate the check digit for the following number:
      0 1 5 0 2 4 6 2 2 ………
   (c) Discuss the types of errors that check digits can identify.
4. (a) Give 2 different ways of carrying out verification checks.
   (b) Give 2 examples of situations where verification would be used.

SOFTWARE

Software refers to a set of instructions written in computer language that tell a computer to perform a specific task, e.g. word processor, spreadsheet, etc. Without software, a computer will be useless. Software is grouped into **systems software and application software.** The diagram below illustrates branches/groups of software:
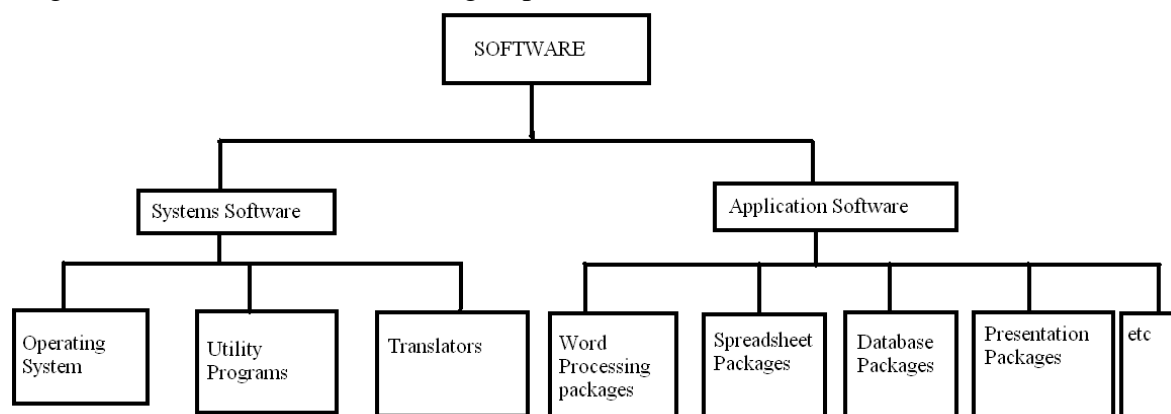
<u>Systems Software:</u> Refers to programs that control and manages the performance of all computer systems. Systems software comprises of: (a) operating systems (b) Utility programs (c) Translators (d) Device drivers.

<u>1) Operating System:</u> - refers to the programs that supervise, control and manage the performance of the computer hardware and software in accordance with set objectives, for example, Windows 7. Examples of operating systems include: Windows 95/98/2000/XP/ VISTA/ Windows 7/Windows 8, Microsoft Disk Operating System (MS-DOS), Unix, Linux, OS/2, Ubuntu, etc.

The operating system is loaded onto the computer by the bootstrap loader. Programs stored on ROM chip runs first and this checks if all hardware components are working normally. It also checks the CPU and the Basic Input output System (BIOS) for errors. If there are no errors, the BIOS will activate the disc drive. The operating system is then found and the computer can boot. Booting refers to the process of loading the Operating system into memory so that it takes control over hardware and software resources of the computer.

Functions of the operating systems:
- Controls movement of data to and from peripherals.
- Acts as a background on which application programs can run.
- **Device management/Input-Output management**: manages hardware components
- Handling of interrupts
- Manage software resources of the computer
- **Memory management** : Manages memory resources of a computer
- Acts as an interface between the user and the computer.
- Scheduling of tasks
- Loading and running of programs
- Provides a log of users for the computer.
- Handling of errors and correcting them where possible. (error handling and reporting)
- Protect hardware, software and data from improper use.
- Control over the selection and operation of input, output and storage devices of the computer.
- Used for spooling
- Maintain user accounts
- Booting and properly shutting down the computer.
- File management

NB: Household equipment like refrigerator do not have an operating system since the processor has one task to perform, no multiple devices and tasks to handle, hence they are cheap.

Features (characteristics) of operating systems:
- Must be reliable in terms of being free from errors and handling of all jobs.
- Must be efficient, that is should be able to use resources fully ensuring good job processing, response time, turnaround time, etc.
- Must be maintainable.
- Must be small in terms of storage space on the disk.

***NB**: **Response time** – the time that elapses from the moment an instruction is given to the computer and the time that instruction is carried out.

Turnaround time – the time taken from the moment a document is produced by a computer and the moment it is used as an input document to that computer again.

Turnaround Document: a document produced by the computer and later used as an input document to the same computer, e.g. electricity bill

NB. Most operating systems are written in low level language. This is for them to quickly coordinate computer activities since they will not be converted as they are already in machine language or less time is needed for conversion if the operating system is written in assembly language. The following must be considered when buying an operating system:
- Hardware type and computer design e.g. windows operating system works well on IBM compatible machines.
- Applications intended for the computer e.g. accounting, stock taking, etc.
- Method of communicating with the computer, that is, use of few or many peripherals and terminals.
- Method of operating the computer e.g. multi-access, multi-programming, etc

Types Of Operating Systems
1. Single User Operating Systems: These are operating systems that allow one computer user at a time in an interactive mode, for example MS-DOS, CP/M, OS/2, etc.
Advantages of Single user operating systems are:
- They are cheap to buy.
- They are interactive, that is, they allow a two way communication between the user and the computer in a conversational mode.
- They ensure better security to data since they only allow one user at a time.
- They provide simple command language.
Disadvantages of Single user operating systems are:
- They are very slow in processing data.
- Most of the computers are dedicated to one task.
- The commands are difficult to learn and to use.
- Commands are difficult to master.
NB- Control Programs: These are programs that monitor hardware operation on the computer.
- Monitor (supervisor) programs: - These are programs that supervise and manage hardware and software elements of the computer

2. Time sharing operating systems: This type of operating system allows many users to use the same processor at a time, using the round robin method by use of time slices. In

Round Robin, each user is given a fraction of a second (time slice) to use the processor so that all users seem not to be sharing the processor.

*NB: - Time slice: A brief period of time during which a particular task (or computer) is given control of the microprocessor in a time-sharing multitasking environment. A computer's processor is allocated to an application, usually measured in milliseconds. Time slice is also called **quantum**.

Multitasking: It is the concurrent execution of two or more programs on the same computer by use of time slices, doing the same job. For example, copying a graph from Microsoft Excel to Microsoft Word. Thus the two programs will be running concurrently, doing a related or same job.

3. Multi Access / Multi user operating systems: It is when many online users access one processor at the same time to make use of multi-programming.

4. Multi-programming: This is whereby two or more programs (tasks) are being processed (run) at the same time on one computer by use of time slices, for example playing music while typing a document. Programs may take turns to make use of the processor, thus when one is using the CPU, others will be using the peripherals. It uses interrupts to pass control from one program to another.

5. Multiprocessing: A type of operating system that allows one computer to have two or more processors but sharing the same memory, e.g. dual core computers.

6. Batch Processing System: - A system in which data is collected over a long period of time, put in groups and processed at one go, without user interaction from start to finish, as in payroll processing. Jobs can be entered at a remote terminal, that is, on a terminal far away from the host computer. Thus batch processing promotes **Remote Job Entry (RJE):** which is the entering of data into the computer through a terminal far away from the host computer.

- For instance, a central computer can process batches of cheques collected from different branches, mostly during the night. If there are errors, the results will also be wrong. Batch processing is very cheap to operate and easy to run. Users can also perform some other tasks while batch processing takes place.

- In batch processing, there is minimum or no human intervention during data processing period. It is used where large amounts of data is processed and where processing does not need to be done immediately, e.g. in Payroll processing, water billing, electricity billing, telephone billing, clearance of cheques, etc).

Payroll Processing
These calculate wages and print payslips. It is the following inputs, processes and outputs:
Inputs: employee details (rate of pay, tax code, bank name, bank account number, etc), number of hours worked, over time, etc.
Processing: Calculation of Gross Salary, Net Salary, deductions, updating master file, etc.
Outputs: printed payslips, updated master file, transfer to bank account, etc.

Billing systems
Used to create bills and invoices to customers. It has the following inputs, processing and outputs:
Inputs: customer details (names, address, account numbers, etc), charge, previous readings, new readings, bank account details, etc
Processing: calculating the number of number of total units, total cost, monthly payments made, outstanding amount, etc.
Output: printed bill showing all details, updated customer file, etc.

Advantages of batch processing are as follows:
- It is less expensive to use.
- jobs can be processed when computer resources are less busy (e.g. during the evening or at night);
- Processing does not need to be done with anyone present.
- Users do not need to be specialists in computers. It allows remote job entry.

Disadvantages of batch processing are as follows:
- Batch processing systems are not interactive.
- Data is processed after a long period of time.
- No action can be taken if anything wrong happens during processing.

b. Translators: - These are programs that convert source code to object code. Translators are in three forms, which are **interpreters, assemblers and compilers.** These will be covered in more detail under Programming Languages.

c. Utility Programs:
These are programs used to perform specific, useful and frequently needed task in a computer system. They usually have one single task to perform on the computer system. Utilities include the following:

i. Virus Scan Utility: These are programs that protect computers from virus attacks, for example Norton Antivirus, AVG, Avast, Esat NOD32, MacAfee, etc.

ii. Sort Utilities: These are programs used to arrange data, files and records into a specific ordered sequence, for instance in ascending or descending order of a given key.

iii. Debuggers: These are utilities used for assisting in correcting errors in programs.

iv. Dump Utilities: These are programs that assist in copying data from main storage to output devices and to other storage devices like the hard drive.

v. Editors: These are programs used to make changes to data already held in the computer.

vi. Peripheral Transfer Utility: These are programs used to transfer data from one peripheral device to another.

vii. System Status Utilities: These are programs that provide information on the state of files, memory, users and peripherals.

viii. File Maintenance Utilities: These are programs used to reorganise programs and to update them.

(d) **Device Drivers**: Programs that allows a device, e.g. printer to work on a given operating system/computer.

Application Software

This refers to programs and their documentation, designed to perform a specific task for the user in daily life, like payroll processing, word processing, etc.

Integrated Package (Application suite) - a collection of application programs purchased as one package, for example Microsoft Office 2010. It is a collection of a word processor, spreadsheet, database and presentation packages bought as one package, for example, Microsoft Office 2010.

Advantages of Integrated Packages are:
- It is cheap to buy as compared to buying single application programs at a time.
- Programs have been tried and tested and therefore are free from errors.
- Programs are designed in a similar way, making it easier to learn others if you are able to use one of them.
- Programs are easier to use and to learn, for example, when designing a database using Microsoft Access.
- Regular updates are provided on the internet or on disks.

Disadvantages of integrated packages are as follows:
- The user is forced to buy the incorporated packages even if he/she needs only one of them.
- They are not tailored for individual user requirements.
- Organisations purchasing them have little or no control over their use.
- The packaged programs can only be modified by the programmers (owners).
- Most of the need regular updating, which may be expensive.
- They have many features that the users might never use yet they buy them.

Methods of Acquiring Software

1. Off-the-Shelf/Generic: This refers to buying generalised software like Microsoft Word from software vendors. **Generalised (generic)** software refers to application programs designed for use in a number of organisations without problems, for example Microsoft Word. A **software vendor** is an organisation that specialises in selling generic software.

Advantages of generic (Off-the-shelf) software:
- Cheaper than custom written (tailor made) packages as development costs are spread over many users.
- the package is available immediately – no need to wait for development period
- Allows large scale sales which bring in considerable revenue which can be used to enable a lot of development to be done.
- They are immediately available in shops.
- They are tried and tested and therefore are free from errors.
- Documentation is always provided in form of manuals, user guides and tutorials that may be in soft or hardcopy.
- Training courses can be available from other end-users.
- Technical support is always available from other users and from the internet.
- Other users of the package can be consulted before purchasing or when a problem occurs.
- Upgrades are always available every year or two.
- It is easy to share files produced by the software with others as chances are they also have the software available to open the file
- sharing of files with other packages is usually easier since they are likely to be compatible (e.g. *Excel* and *Word*)

Disadvantages of Generic Software:
- May not meet the individual needs of an organisation.
- May not run on the organisation's hardware.
- May not interface with other software already in use in the organisation.
- Organisations purchasing them have little or no control over their usage.

- Organisations purchasing them have no right to modify them.
- The software can be very sophisticated and will usually include large sections that you will never use (e.g. Excel or Word)
- may be very complex to learn because of the complexity caused through having unwanted features

2. Tailor-made Software (bespoke/user application software): These are programs specifically designed to meet the unique needs of only one organisation, for example a bank. The organisation would employ or hire an analyst / programmer who will first asses the needs of the organisation before designing a program that will solve the problems of the organisation.

Advantages of Tailor-made software
- Easier and more intuitive to use.
- Much better customer support since they will be in direct contact with the software designers.
- Specifically designed for the application and therefore more efficient and will only contain the features wanted by the user.
- can be customised to interface with all other software within the company thus preventing software clashes
- easier to use since very specific and the writers of the software can also be involved in the training of staff which will be geared towards their requirements
- can be modified/updated as the company's requirements change

Disadvantages of Tailor-made software:
- It is very expensive to develop.
- They take too long to develop and to implement.
- If you pick the wrong developer you could end up with an application that is unstable, unreliable and full of bugs
- very dependent on the suppliers of the software; if they go out of business there will be little or no support if problems occur
- less likely to be as well developed/tested as off-the-shelf software
- difficult to tell how good the final software package will be

***NB**: **A programmer** is a person who specialises in designing, coding and testing computer programs.

Software House is an organisation that specialises is developing software; this includes both generic and tailor-made.

Special Purpose Application Software: - These are programs designed for one specific business purpose, for example Pastel for accounting purposes.

Advantages of Off-the-Shelf Software Over tailor-made software:
- Off - the - self software is cheaper to buy while tailor-made software is expensive.
- Off-the-Shelf software has been tried and tested hence free from errors while tailor-made software may have some errors.
- Off-the-Shelf software is easier and faster to implement while tailor made software takes long to implement.
- Off-the-Shelf software is used by many organisations; therefore users can share information on its usage while tailor-made software is only used by one organisation.
- Off-the-Shelf software has regular updates available for download on the internet while tailor-made software does not.

Advantages of tailor made software as compared to Generic Software:
- Tailor-made software is designed to meet the requirements of an organisation while Off-the-Shelf software might not meet the needs of an individual company.

- Organisations have full control over tailor-made software as compared to off-the-shelf software which is controlled by the programmers.

Types of Application Software:

These include:

1. Word Processing Packages:

These are application packages used for creating, editing and formatting text documents like letters and reports. Examples of Word Processing packages include Microsoft Office Word, WordPerfect, WordPro, Notepad, etc. Word processing packages have the following **advantages over the typewriter**:

- Produces more attractive documents.
- Word processors are less noise than typewriters.
- Documents can be edited and formatted before printing, which reduces spelling and other typing mistakes on printed documents.
- Typed documents can be stored in the computer for future use.
- Document layout can be viewed on the screen before printing and can be changed easily.
- A word processed document can be printed more than once.
- Other text and diagrams can be added without the need to retype the document.
- Word processors can move some parts of text to another part of the document easily (using copy/cut and Paste feature).
- They have the ability to delete words, sentences and paragraphs neatly.
- They are less manual than typewriters.

Features of Word processing Packages

- ability to set the page size and page orientation (portrait/landscape)
- ability to change font style and font size (e.g. *arial, courier, times new roman*, etc.)
- ability to change margins (top, bottom and sides)
- page format (e.g. paragraphs, columns, etc.)
- importing text, graphics and pictures into the document body from other packages like Microsoft PowerPoint and Excel.
- inserting and deleting text
- cut and paste/copy and paste (to prevent the need to re-type sections of text or to move/remove text)
- search and replace words
- word wrap (e.g. auto adjust a line to fit into paragraph alignment such as straight
- file management (create/delete/move/search for files)
- headers and footers and the automatic numbering of pages
- graphics (embed drawings and graphs into the document)
- use macros
- merge (merge text files from one file into another e.g. mail merge)
- ability to send documents to a printer
- carry out a word count on the document
- add and manipulate tables in the main body of the document
- windows (edit 2 or more documents at the same time)
- WYSIWYG *(what you see is what you get)* – preview document to see how it will look when printed
- spell checkers, language check and thesaurus
- Simple translation from one language to another; for example, from English to French.

****NB**: **Editing**: the process of correcting mistakes in a document, for example, spelling mistakes.

Formatting: making a document look more attractive by bolding, underlining, inserting borders, etc

2. Spreadsheet Packages: These are application programs used to manage and analyse statistical, numeric and financial data, for example Microsoft Office Excel, Lotus 1-2-3, SuperCalc, etc. The structure of a spreadsheet is as follows:

Features of Spreadsheet packages
- Can format text (Bold, underline, …)
- Can change font size and font type
- Uses functions/ formulae to make calculations on data. The functions can be user-defined or in-built functions
- Ability to inset boards on cells
- Can import and export text
- Can create graphs on given data, e.g. column graphs, pie charts, etc
- it is made up of columns and rows; each row is identified by a number and each column is identified with a letter (or letters)
- can use **Autofill** feature
- Each cell is identified by its column id and row id e.g. A4, ET300 etc. Cells can be given as cell ranges, e.g A4: G4.
- a cell may contain a *label* (text entry such as Surname, Date Of Birth,..) or a *value* (which can be a number, a date, a formula, result of a calculation, or currency)
- the cursor identifies the current cell selected; it is possible to click on to a cell and a "+" sign appears in the bottom right hand corner; by dragging the formula down it is possible to *replicate* it in other cells
- etc……

Problems Associated With Spreadsheets:
- capacity (i.e. maximum number of rows and columns) can be limiting when dealing with large data sets
- security issues in some spreadsheets (i.e. if you can open a spreadsheet you can also change any part of it; this can lead to fraud
- lack of concurrency; usually only one person can work on a spreadsheet at any given time (databases are better in this aspect since they can usually be opened by more than one user at a time)
- because of their structure it is easy to enter an error (whether on purpose or by mistake) by entering data in the wrong cells or dependencies among cells incorrectly applied

3. Presentation Packages:
- These are programs used for designing slides for a presentation to an audience, for example Microsoft Office PowerPoint, Lotus Smart Suite, etc.
- Presentation packages include text, pictures, sound, animation, graphics and tables, thus being multimedia.
- Presentations are colourful and attractive.
- Speakers and projectors are needed.
- Presentation packages have the following **features**:
  - Have Clip art. Can accommodate images and graphics.
  - Can use sound, video and animation.
  - Incorporate Word Art.
  - Have facility to insert charts and graphs.

*NB: Animation: - Creating illusion of moving sequence using a series of still images as done in movies and cartoons.

4. Database Packages (DBMS): Refers to programs used to create and maintain databases for a specific application area.

They are used for maintaining and providing interface been users and the database and to interface the database and other application programs.

Examples of database packages include Microsoft Office Access, Oracle, Dbase IV, MySQL, etc

Properties/features of databases
Most database packages have the following features:
- (a) **Tables**: These are equivalent to files and therefore are used to store data. The data is stored in rows and columns. Each row in a table is called a *record* which is made up of a number of *fields* (columns in the table). The data type in the fields is usually either text, numeric or date/time. Most databases contain a number of tables which are usually linked together in some way.
- (b) **Forms**: Forms are commonly called *data entry screens* since they are the user interface which allows data in the tables to be viewed, entered or edited. Forms permit the control of how other users interact with the information in the database e.g. only allow certain fields to be seen or only allow certain operations to be carried out . This subsequently helps the protection of the information and also ensures it is entered correctly
- (c) **Reports**: Reports are produced as a result of questions such as "date>=01/01/1975". The data on report is extracted from queries or tables as per user requirement. They display certain required data as needed by the user, e.g. after searching or filtering of data. Reports can be printed out as hardcopy, or viewed on the screen or exported (e.g. to a word processor, an email message, etc.).
- (d) **Queries**: Queries are questions that request certain data from tables, e.g, Amount <200. It can also be an instruction to search data which meets a certain criteria from table and display it on the screen in form of another table created from the original table. Most commonly allow information to be retrieved from tables. They also allow filtering so only the records required are seen.
- **(e) Macros**

  A macro is a name or key that represents a series of commands or key strokes. Many applications allow single word or single nominated key on a keyboard to perform a whole series of actions. Macros can be either written as required and then stored or stored in a library for future use. Macros can be very sophisticated and save the operator a lot of time. For example, the name and address in a word processor could be set up by pressing key **F1** and the system brings information from a related database

5. Graphics Packages: Refers to programs used to create and edit graphs, diagrams, drawings, charts and plans for buildings, for example Microsoft Paint, Harvard Graphics, Corel Draw, Real Draw, etc. Computer graphics are images designed for logos, commercial and news inserts during television advertisements or transmission.

6. Communication Software: These are programs that allow users to communicate on networked computers and to log on to the internet, for example TCP/IP software, Client – server software, e-mails, etc.

*NB: - **Log On**: to provide a username and password for the user to gain access to a computer or computer network.

7. Desktop Publishing (DTP) Packages: It is an extension of word processors that incorporates images and text for creation of attractive and professional documents for publication purposes. Examples of DTP packages include Microsoft Publisher, PageMaker and QuarkXPress. DTP is used to create brochures, magazines, wedding cards and newsletters.

Features of DTP include:
- They have a graphic program for inserting graphics in the document.
- They have a page composition program.
- They incorporate columns on one page.
- They have frames for positioning texts and graphics.
- They have templates used for recording document properties like page size, margins, etc.
- They have style sheets used for making consistent main texts, headings and subheadings.

Requirements for DTP:
(a) **A Scanner**: - for capturing images or hand drawings on paper, for example photographs
(b) **High Resolution Monitor** with graphics capabilities: - For viewing publication during design stage.
(c) **Colour Printer**: For printing high quality and colourful documents.
(d) **Digital camera/webcam/cell-phone with a camera**: - for taking and storage of photographs that will be incorporated into the computer.
(e) **Keyboard**: For typing in text
(f) **Mouse**: - For adjusting size of pictures and for drawing purposes.
(g) **Desktop Publishing (DTP) software**.

Advantages of Desktop Publishing:
- Users have more control over text layout compared to word processors especially over formatting and layout of text and images.
- Lots of different files can be brought together on the same document.
- Produces colourful and attractive documents for commercial purposes like brochures.

Differences Between DTP and Word Processors
- most word processors force users to work on a document in a linear fashion (i.e. paragraph by paragraph and page by page); with DTP it is possible to place elements on the page and then move them around as you wish to create the desired product.
- elements repeated throughout a document (e.g. a company logo) can be placed in *master pages* rather than setting up each page individually as would be the case with a word processor.

- Text is usually imported from a word processor or is typed into the document directly using a *frame*. This allows you to create the layout first, link the frames together and add the text into the *frames* later (e.g. in newsletters and magazines where layouts are created before any of the actual text becomes available).

8. Authoring Packages (Authorware): Software that can be used to write interactive, hypertext or multimedia computer programs without the technically demanding task of computer programming. Also used in multimedia presentations. These programs can be used for developing databases and material for Computer Aided Instruction (CAI).
Authoring tools require less technical knowledge to master and are usually used for applications that present a mixture of text, graphics, and audio/music files. *Authoring tools* usually allow the creation of the actual required application by linking together *objects* which can be text, graphics, music file, etc. By defining the relationship between *objects* it is possible to produce very useful and eye catching applications.

(9) **Web Browsers**: Software used to open web pages on the internet, examples are: Mozilla Firefox, Microsoft Internet Explorer, Safari, Opera, etc.

(10) **Search Engines**: These are packages used for searching data for the user from the internet, e.g. Google, yahoo, etc.

*__NB__: - **Specialist Packages for Business:** These are packages for use in a specific business environment, for example, Pastel for accounting purposes.
*__NB__: - **Install**: - to add programs to the computer. Therefore to uninstall is to remove programs from the computer.

Factors to consider when purchasing an application package:
- Application intended for.
- Easiness of installation.
- Mode of processing (single user, multi user, etc).
- User friendliness.
- Availability of support personnel.
- Availability, readability and clarity of documentation.
- Memory requirements.
- Hardware requirements.

Types of Systems
1. Real Time Processing System: - An online system in which individual, discrete transactions are processed as they occur to influence the activity currently taking place, as in airline reservation. Results of the process are produced immediately. The system response quickly and give feedback of a request. Thus the system is interactive in nature. Such systems include airline reservation systems, hotel reservations, stock control, etc.

Real Time Processing System can also be called Transaction Processing System (or Real Time Transaction Processing Systems): this is a real-time (or pseudo-real-time) transaction processing system whereby only individual items of data need immediate processing, results and files are updated instantly e.g., airline reservation, balance enquiry at an ATM, etc. Response to a query needs to be very fast and once a seat is booked it needs to marked as "not available" immediately to avoid any risk of double booking.
Using this example of booking seats on a flight, the following sequence of events would take place:
- customer/travel agent contacts the airline
- the customer/travel agents types in the day/time of flight and number of travellers

- the customer/travel agent types in the departure airport and the destination airport
- the airline database is searched and availability of seats checked
- if seats are available on the required day/time then a booking is made
- the database/file is updated immediately to indicate that these seats are no longer available and prevents double booking from occurring
- if no seats are available a message is sent back to the customer/travel agent
- this uses real time (transaction) processing since the files are updated in real time; interrogation of files will have access to totally updated information

Transaction processing's requirements include:
- A large quantity of hardware support.
- Large and fast main storage, over 1 GB.
- Large and fast backing storage like hard drives of about 300 GB.
- Efficient communication equipment like fibre optics, satellites, etc. Efficient, secure and reliable operating systems.
- **However**, transaction processing systems are very expensive to run.

2. Real time process control
This is a real-time system which uses sensors and feedback loops (i.e. the output can influence the next input to the system.). Used in **safety critical** situations like patient monitoring, monitoring and control in nuclear power stations, etc. It uses actuators, sensors, DAC, ADC to continuously and automatically monitor physical quantities like temperature in a system. It differs with real time (transaction) processing system in that: In real time (transaction) processing system, files are often updated in real time (e.g. when booking flights on an airplane); but in real time process control, physical quantities (such as temperature) are continuously monitored and the input is processed sufficiently quickly to be capable of influencing the data source

3. On-Line System: A system that is directly linked to the host computer for real-time communication and provides interaction between the user and the job, as in POS terminals in supermarkets. In networked computers, the terminals must be directly linked to the host computer. Examples include ATM systems in banks, airline reservation systems. Online systems can just be for information retrieval. Information retrieval systems are there for users to access certain information promptly as on the internet. In contrast, **offline systems** are computer systems that work without being directly connected to the host computer.

4. Network Systems: - A system in which processing is carried out independently in more than one location but with shared and controlled access to some common facilities like file storage.

5. Control System: - A system in which one or more computers are used to monitor the operations of some non-computer equipment like in oil refineries. Control systems involve monitoring and logging of physical quantities, provide an analysis of performance and allows some user interaction. Feedback is an essential element as well as timing. Most control systems are real-time systems, e.g. oil refining, chemical processing, traffic control, etc.

6. Automated Systems: - These are control systems that are dedicated to one particular task and lack the ability to collect and analyse data as in digital cameras. They do not allow for or act on user interaction, e.g. washing machines, cameras, watches. Most control systems have embedded computers systems inside them.

7. Multimedia Systems: - Are computer systems that enable representation of data in a number of formats like sound, pictures, films, video, etc. Multimedia systems are used in

commercial applications (advertising, journalism, presentations, etc.), entertainment (special effects, video games, fine arts, etc.), education (CBT training, uses in virtual reality training, etc.). A computer that can be referred to be a multimedia system should have at least the following:
- a CD – ROM/DVD-ROM drive,
- speakers, large RAM size,
- large disk storage space,
- sound card
- video card and
- multimedia software like Windows Media Player and
- other software like sound drivers.

8. Distributed (decentralised) Systems: A system whereby processing is done independently in more than one location but with shared and controlled accessed to common facilities, like file storage as applied in departmental shops. These systems are normally found in departmental shops, bank branches that will be linked together, etc.

Advantages of distributed systems:
- Users feel more involved and responsible and this increase motivation.
- Systems often meet user specific needs and requests for changes are more readily met.
- Costs of physical and electronic movement of data are reduced.
- The total breakdown of information processing disappears.

Disadvantages of distributed systems:
- There is often lack of coordination and control.
- It is difficult to impose standardisation, adequate security measures and sharing of data and know-how.
- Difficult to obtain integrated information for top management. Duplication of data is rampant.
- Excessive investment in hardware, software and personnel is involved.

9. Centralised systems: This is whereby processing is carried out at one central location for an organisation with a number of branches. Users in other locations can view data and utilise it but with limited capabilities. Centralised processing has the following advantages:
- Hardware within the organisation will be compatible and can be linked.
- The organisation gets better deals in terms of maintenance contracts. Employees do not have to learn new systems when they move from one department (or branch) to another.
- It is easier to coordinate staff training courses using the same software and hardware for all departments (or branches).
- There is better control over use of unlicensed software.
- Data can be exchanged easily between similar types of hardware and software

Disadvantages of Centralisation:
- Requires high initial capital investment of sophisticated equipment, operating systems, well developed communication systems and complex application packages.
- Requires highly qualified and experienced personnel to run it.
- A system failure will paralyse the entire system unless expensive backup system is provided.
- Users feel not being fully involved and therefore are not motivated.

The choice of processing depends on:

- Cost of hardware: online systems are more expensive to install, including installation of communication systems like telephones and satellites.

- Volume of data involved: batch processing is appropriate where very large data is handled.

- Frequency of data change: banks need online systems for customer data changes more frequently than in payroll processing systems.

FILE HANDLING

Types of files

1. Master File: It is a permanent file that is kept up-to-date by applying transactions that occur during business operations. It contains permanent (static) and semi-permanent data. Static data stored in database files can include Surname, First names, Date of birth, etc.

2. Transaction Files: These are temporary files that contain data that can change regularly, e.g. on daily bases and it is used to update the master file. This includes sales per day, student mark in a weekly test, etc. Transaction files are used to update master files.

3. Reference files: These are files that contain permanent data which is required for viewing purposes only. The file can be displayed on the screen or printed without altering it in any way. This includes data on tax bands, formulae, etc. No changes to files are done.

4. Data file: A set of related records (either written or electronic) kept together.

A. Fixed Length Records

These are records that allocate a specific amount of space for data, mostly a specific number of characters. For instance, a school keeps student records in a fixed length record. The **student number** has **6** characters, **Surname** was assigned **10** characters, **First Name** is given **10** characters, **Date of Birth** has **6** characters, **sex** has **one** character and **class** has **2** characters only in that order in the computer database file. In total, the length of each record is 35 characters.

The following student details are to be entered into the computer:

Student Number: *012999,* **Surname**: *Kapondeni,* **First Name**: *Tungamirirai*

Date of Birth: *7th of February 1978,* **Sex:** *Male,* **Class**: *Form 4A*

When entered into the database, the record will appear as follows:

Student Number	Surname	First Name	Date of Birth	Sex	Class
0 1 2 9 9 9	K a p o n d e n i	T u n g a m i r i r	0 7 0 2 7 8	M	4 A

From the table above, it can be noticed that:

- The Sex field is coded to accommodate only the letters *M* or *F*. This is shorter and therefore faster to enter data into the computer and to search records than entering the words Male or Female.

- The Surname *Kapondeni* is shorter than the allocated 10 spaces. The other spaces will remain idle (unoccupied).

- The First Name *Tungamirirai* is too long than the allocated spaces and therefore extra characters will be cut.

Fixed length records have the following advantages:

- Entering data is faster as records are shorter and less typing is required.
- Easy to search data
- Less data entry errors are encountered.
- It is faster to carry out searches.
- Faster to do validation checks and procedures.
- They are easier for programmers to work with than variable length records.

- They allow an accurate estimate of disk storage requirements. Thus disk storage space can be easily managed as records occupy a specific number of characters.
- They are very easy to update

However, fixed length records have the following disadvantages:
- Can lead to wastage if disk storage space if used to store variable length data. For example, not all surnames are of the same length.
- Some spaces may lie idle as data entered will be shorter than the space allocated.
- Some data to be entered may be too long for the space allocated and therefore will be cut.
- Not flexible to work with

B. Variable Length Records

These are records that allow data to occupy the amount of space that it needs. They allow data with varying (different) number of characters or sizes. The number of fields may also vary. They usually show where the field or record starts and ends, for example:

| 0 | 1 | 2 | 9 | 9 | 9 | * | K | a | p | o | n | d | e | n | i | * | T | u | n | g | a | m | i | r | i | r | a | i | * | 0 | 7 | 0 | 2 | 7 | 8 | * | M | * | 4 | A | ˜ |

NB:- * *Indicates the end of field marker, and the ≈ indicates the end of record marker*

Variable length records have the following advantages:
- They are more economical in terms of usage of disk storage space as they do not allow spaces to lie idle.
- Data entered will not be cut but appears as entered no matter how long it is.
- may reduce time taken to read file/transfer data
- enables as many fields as possible to be added to a file

However, variable length records have the following disadvantages:
- End of field and end of record markers occupy disk storage space that might be used to store data.
- Difficult to update (add or delete) as the transaction and master files might have different lengths.
- more complex to use
- more complex to manage
- Hard to search data in the files

File Organisation

Refers to the way in which records in a file are stored, retrieved and updated. This affects the number of records stored, access speed and updating speed. The most common methods of file organisation are: Serial **File Organisation, Sequential File organisation, indexed – sequential file organisation and random (direct**) file organisation.

1. Serial File Organisation: This is whereby data is recorded one after another as they occur, without any definite order, as supported by magnetic tapes. Data is stored according to arrival time. Data is read from the first record until the needed data is found. New records are added to the end of the file. Serial file organisation is not appropriate for master files since records are not sorted and therefore are difficult to access and to update. It is faster to find records at the beginning of the file, but takes too long to find records towards the end of the file. Serial files are suitable for temporary transaction files since records are not sorted.

Serial files promote Serial Access: whereby records are accessed by reading from the first until needed record is found in an unordered file, e.g on magnetic tape.

2. Sequential File Organisation: This is whereby records are sorted into a key sequence, that is, in ascending or descending order of a given key filed as on magnetic tapes. Sequential files organisation is appropriate for files with a high hit rate like payroll

processing. They are suitable for master files since they are ordered. However, it takes too long to access records towards the end of the file since the records are accessed by reading from the first record until the required data is found. However, searching of records at the beginning of files is very fast. Adding of new records is difficult as this is done by re-entering the data and the new record is inserted at its right position. It is time consuming to update such records. Suitable for master files since records are sorted. This is used where all records need processing, e.g payroll.

Sequential Files promote sequential Access: **Sequential Access** is whereby records are retrieved by reading from the first record until the needed record is found in an ordered list of records, e.g. on magnetic tape. Sequential access occurs where records are ordered using a key field.

3. Indexed-Sequential Files: This is whereby records are ordered in sequence based on the value of the index or disk address as supported by hard disks. This is used for storing master files records since the records are ordered. It is also suitable for real time processing applications like stock control as it is fast in accessing records and in updating them. It provides direct access to data as on hard disks, diskettes and compact disks.

4. Random (Direct/hash/relative) File Organisation: This is whereby records are stored in no order but accessed according to their disk address or relative position, as supported by hard disks and compact disks. The address of the record is calculated using the **hashing** algorithm. It is appropriate where extremely fast access to data is required as in airline reservation. Updating of records is in situ, very simple and very fast. Hard disk, compact disks and diskettes promotes random file organisation.

Random File organisation promotes **Random/Direct Access** to records: Direct access is hereby records are retrieved randomly by going straight to the needed record by using address of data, as supported by hard disks, compact disks, memory sticks, etc.

File Processing

Refers to any form of activity that can be done using files. This includes: file referencing, sorting, maintenance and updating.

1. File Referencing/Interrogation: This involves searching of record and displaying it on the screen in order to gain certain information, leaving it unchanged. The record can also be printed.

2. Sorting: Refers to a process of arranging (organising) records in a specific ordered sequence, like in ascending or descending order of the key field.

3. Merging Files : This is the process of combining two or more records into one. Below is an example of how records can be merged:

Record A (sorted)   **Record B (unsorted)**

12	34	71	78	101		103	67	3	90	12

Record C (Merged and sorted for records A and Record B)

3	12	34	67	71	78	90	101	103

4. File maintenance: This is the process of reorganising the structure of records and changing (adding or removing or editing) fields. This can be due to changes due to addition or deletion of records.

5. File Updating: Updating is the process of either adding new record, deleting unwanted records or modifying existing records. It involves making necessary changes to files and records. Mostly master files are updated and they must be up-to-date (contain accurate and most recent information)**.**

For updating to occur, any one of the following must have occurred:
- A new record has been entered.
- Deletion of an unwanted record.
- An amendment (change) to the existing data has been made, e.g. change in date of birth only.

The most common methods of file updating are: Updating **in situ** and Updating **by copying**.

a. Updating by copying

This happens in sequential file updating process. This is done through the following steps:
- A record is read from master file into memory.
- A record is read from transaction file into memory.
- Record keys from each file are compared.
- If record keys are the same, the master file is updated by moving fields form transaction file to the master file.

In sequential file updating, it is recommended to keep at least three **master file** versions that will be used for **data recovery** in case of a system failure or accidental loss of data. The first master file is called the **Grandfather** file, the second master file is called the **father** file and the third master file is the **son** file. This relationship is called the **grandfather-father-son** version of files. **The process of keeping three versions of master files (grandfather-father-son) as a result of sequential file updating is called File Generations**. Thus the first master file (grandfather file) is called the first generation file, the second master file (father file) is called the second generation file and the third master file (son file) is the third generation file. The following diagram illustrates the sequential file updating process:
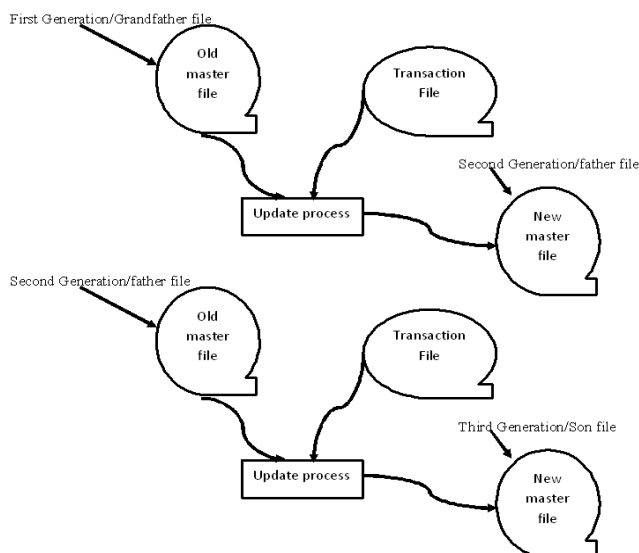
*NB: - Always create data backups on compact disk or hard disks and re-run the old master file with the transaction file if the computer system fails or if data is lost. This is a data recovery method that works well.

*NB:- A backup is a copy of file(s) on an alternative medium like CD-ROM which is kept in separate location in case the original file is damaged or lost and will be used for recovery purposes. The original files could be deleted accidentally, deleted by hackers, corrupted by system failure or could be corrupted by hackers.

b. Updating by overlay (in situ):

In this case, a record is
- accessed directly,
- read into memory,
- updated and then
- written back to its original position (in situ).

This occurs in random and indexed-sequential files, thus on devices like hard discs and memory sticks.

PROGRAMMING CONCEPTS

Definition of terms:

- **Program**: a set of detailed and unambiguous instructions that instructs a computer to perform a specific task, for example, to add a set of numbers.
- **Programming**: A process of designing, coding and testing computer programs
- **Programmer**: A person who specialises in designing, coding and testing computer programs
- **Problem**: any question or matter involving difficulty or uncertainty and is proposed for solution.

Programming Languages

A programming language is a set of symbols in computer language that are used in coding computer programs. A programming language is a specially written code used for writing application programs e.g C, Pascal, COBOL, BASIC, C++ and Java.

Programming languages are of the following types:

1. Low Level Languages (LLL): These are programming languages used to write programs in machine code, that is in zeros and ones or in mnemonic codes. Low level language is in two forms: **Machine Language** and **Assembly Language**.

a. Machine Code (Language) is the language used to write programs in binary form (zeros and ones). Machine language has the following **advantages**:
(i) Programs run faster since they are already in computer language. There is no need for conversion as programs are in machine language.
(ii) Programs occupy very small disc storage space by storing just 1s and 0s.

Disadvantages of Machine Language:
- They are very difficult to learn.
- They are difficult to understand.
- Very difficult to use and takes too long to find an error in a program.
- It takes too long to develop working programs.
- They are machine dependent (they can only work on type of computer designed for and not work on other computers)

b. Assembly Language: These are programming languages that use mnemonic codes in coding programs. Mnemonic codes are abbreviations used in coding assembly language programs, for example, LDA for Load, ADD for Addition, etc. Mnemonic codes are very close to machine code, hence are low level language assembly language codes

Advantages of Assembly language:
- One assembly language instruction corresponds to one machine code instruction and therefore translation is easier and faster.
- Programs run faster since they are close to machine code.
- They occupy very small disk storage space hence are economical to use.
- Easier for a programmer to use than machine language.

Disadvantages of Assembly Language
- They are very difficult to learn.
- They are very difficult to understand.
- Takes too long to develop working programs.
- They can be machine dependent.
- Longer code due to 1:1 relationship to machine code

2. High Level Languages (HLL): These are programming languages that use English-like statements in coding programs, for example COBOL, Pascal, BASIC, etc. There are so many high level languages because each language is designed for a specific problem to be solved in our daily lives. For example BASIC was designed for learning purposes, COBOL for business applications, FORTRAN for scientific purposes, etc. Below is an example of a BASIC program that accepts two numbers entered through the keyboard, adds them and display the result on the screen:

        INPUT "ENTER FIRST NUMBER.", A
        INPUT "ENTER SECOND NUMBER.", B
        SUM = A + B
        PRINT SUM
        END

Programs written in High Level Language are first converted to machine code before running.

Advantages of High Level Languages:
- They are easier to understand since they are written in English-like statements which are more readable.
- They are easier to learn.
- It is easier to debug.
- They are portable (run on any machine)
- Have shorter code due to 1 : many relationship to machine code
- They are problem oriented and therefore can be used on any computer (not machine dependent)

Disadvantages of HLL
- Takes long to run since they need to be first converted to machine code.
- They occupy a lot of disk storage space as compared to low level languages.

Factors to consider when choosing a programming language
- Nature of the application.
- Availability of needed facilities in the programming language for system implementation.
- Availability of compatible hardware.
- Availability of expertise of the programmers.

Translators

These are programs used to convert source code into machine code, and are in two types, which are **interpreters, compilers and assemblers**, which are further explained below:

1. Interpreters

These are programs that convert (translate) and run one instruction of a program at a time before going to the next, until the end of the program, e.g. the BASIC interpreter. They do not produce the machine code version of a program; hence conversion is repeated when you run the program again. Thus interpreters retain source code. The interpreter must be present in the computer for the program to run.

Functions of Interpreters
- They check syntax error in a program statement.
- They translate an instruction into machine language and run it before going to the next.
- Allocates storage space to variables.

Advantages of interpreters
- It is easy to find and correct syntax errors in interpreted programs.
- It is very fast to run programs for the first time.

- It is very fast to run small programs.

Disadvantages of interpreters
- They are very slow in running very large programs.
- They do not produce an object code of a source code and hence difficult to use.
- The interpreter must be present in the computer for the program to run.

2. Compilers

These are programs that convert a high level language program into its machine code equivalent at one go and then run it, e.g. the COBOL compiler. Thus it translates the entire program before running it. Once compiled, the program no longer needs conversion since the machine code version is the one that will be run, until some changes are made to the program code. Thus a compiler produces an object code of the program. The computer must have a compiler for translation.

Functions of Compilers
- They check syntax errors in program statements.
- They allocate storage space to variables.
- Translate the whole program into machine code at one go.
- Run an object code of the program.
- Produces a program listing which indicates position of errors in a program.

Advantages of Compilers
- Compiled programs runs faster since the object code is run.
- Compilers indicate the line numbers with syntax errors and therefore assist programmers in debugging programs.
- They are appropriate even for very large programs.

Disadvantages of Compilers
- Slower than interpreters for running programs for the first time.
- The compiler must be present for the translation process to occur.
- They can cause the computer to crash.
- Difficult to find errors in compiled program.

***NB**: **Source Code** refers to the program written in English-like statements (High Level Language) by the programmer.

Object Code refers to a machine code version of a source code. All programs written in source code must be converted to object code for the computer to understand them.

3. Assemblers: These are programs used to convert assembly language instructions into machine language. Other uses of assemblers include:
- They generate machine code that is equivalent to assembly language.
- They are used to check the validity of instructions, that is, checking for syntax errors in an instruction.
- They also assign memory locations to variables.

Difference between High Level Languages and Low Level Languages

	High Level Language	Low Level Language
1	Written in English like statements	Written in 1s and 0s (machine code) or in mnemonic codes.
2	Easier to work with	Difficult to work with
3	Easier to understand	Difficult to understand
4	Are problem oriented	Machine oriented
5	Slower in execution since they need to be	Faster in execution since they are in machine code

	first converted to machine code before running	already.
6	Occupy large disk storage space on the computer	Occupy small disk storage space on the computer
7	They are machine independent	They are machine dependent
8	They are portable	Not portable

Top-Down Program Design

Refers to the splitting of a program/task/problem into simpler subtasks called modules which will be easier to solve. A complex problem is split into several smaller sub-problems that are easier to tackle. For example, a program can be split into modules to Accept Number, Add, Divide, Subtract and to Display Results. Modules are also called procedures, routines, sub-routines or functions. The splitting of a problem into a series of self-contained modules is called modularisation (modular programming).

Advantages of modularisation (modular programming)

- Programmer can concentrate at one task at a time.
- Modules are simpler and easier to understand and to solve.
- Modules are easier to test and to debug.
- Program modification is easier since changes are isolated with specific modules.
- More experienced programmers can be assigned complex modules.
- It saves programming time by sharing tasks.
- A large project will be easier to monitor. It is easier to update (modify) modules

However,

- It may be difficult to link the modules together.
- There could be problems of usage of variables as similar variable names may be referring to different sets of data. They may also vary in scope.

*NB: Library programs: this refers to a collection of standard programs and subroutines that are stored and available for immediate use by other modules in the system. Library programs are referenced by most modules in the systems.

*NB: Stepwise refinement: a technique used in developing a system by breaking it into modules and then work on the internal working of a module.

***NB**: The difference between a procedure and a function is that a **procedure** is a sub-program that do not return a value while a **function** is a sub-program that returns a value.

Algorithms

A set of instructions describing the steps followed in performing a specific task, for example, calculating change. Algorithms are not necessarily written in any specific language. Algorithms can be illustrated using the following:

Descriptions, Flowcharts, Pseudocodes, Structure diagrams.

Advantages of algorithms

- not biased towards any programming language
- easy to convert to a program code or flowchart
- easy to determine logic errors
- has finite steps which lead to a solution

Disadvantages

- time consuming to design, i.e. first convert to flowchart, then to program code
- most people find them difficult to learn

a. Descriptions: These are general statements that are followed in order to complete a specific task. They are not governed by any programming language. An example is as follows:

Enter temperature in ^oC
Store the value in box C
Calculate the equivalent temperature in ^oF
Store the value in box F
Print the value of box C and F
End the program.

b. Pseudocodes: These are English-like statements, closer to programming language that indicate steps followed in performing a specific task. They are however independent of any programming language. An example is as follows:

Enter centigrade temperature, C
If C = 0, then stop.
Set F to 32 + (9C/5)
Print C and F
End

Variables
Definition: A variables is a memory location that can store a value that can change during program execution.
Naming variables: Each programming language has its own way of naming variables. However, the following conventions are common:
  - a variable should not be a reserved word. A reserved word is a word with a specific meaning / function in that programming language, e.g. Print, else, are reserved words in BASIC
  - Variables must start with an alphabetic character, not with digit.
  - It is wise to name a variable using the data it stores, e.g. surname (to store surnames), DOB (to store a date of birth), etc. Thus it must be meaningful to avoid confusion
  - Must not be too long
  - Must be one word

Control Structures in Pseudocode
A number of control structures are used in designing Pseudocodes. These includes: simple sequence, selection and iteration (looping/repetition).

i. Simple sequence: This is whereby instructions are executed in the order they appear in a program without jumping any one of them up to the end of the program. Statements are executed one after another in the order they are. It is simple and avoids confusion. Example:

Enter first number, A
Enter second number, B
C = A + B
Print C
Stop

ii. Selection Structure:
This allows one to choose the route to follow in order to accomplish a specific task. Selection is written using the IF ....THEN...ELSE statement or the CASE statement.

IF...THEN ...ELSE statement: A programming structure that allows the user to choose one from at least two routes of solving a problem. The following Pseudocodes compares two numbers entered through the keyboard and determines the bigger one.

Enter first Number, A	Enter first Number, A	Enter first Number, A
Enter second number, B	Enter second number, B	
IF A>B THEN	IF A > B THEN	Enter second number, B
Print A is bigger	Print A is bigger	IF A>B THEN Print A is bigger
ELSE	ENDIF	
IF A<B THEN	IF A < B THEN	IF A<B THEN Print B is bigger
Print B is bigger	Print B is bigger	
ELSE	ENDIF	IF A=B THEN Print Numbers are equal
Print Numbers are equal	IF A = B THEN	
ENDIF	Print Numbers are equal	END
ENDIF	ENDIF	
END	END	

The above 3 Pseudocodes produces the same result.

CASE Statement: This is an alternative to the IF...THEN...ELSE statement and is shorter. For example:

     Enter first Number, A
     Enter second number, B
     *Enter operand (+, -, * /)*
     CASE operand of:
          "+": C = A + B
          "-": C = A-B
          "": C = A*B*
          "/": C = A/B
     ENDCASE
Print C
END

Iii. Repetition/Iteration/Looping:

A control structure that repeatedly executes part of a program or the whole program until a certain condition is satisfied. Iteration is in the following forms: FOR...NEXT loop, REPEAT... UNTIL Loop and the WHILE...ENDWHILE Loop.

a. For...Next Loop: A looping structure that repeatedly executes the loop body for a specified number of times. The syntax of the For...Next loop is as follows:

     FOR {variable} = {starting value} to {ending value} DO
          Statement 1
          Statement 2   *loop body*
   *................*
     NEXT {variable}

A group of statements between the looping structures is called the **loop body** and is the one that is repeatedly executed.

The **For...Next** loop is appropriate when the number of repetitions is known well in advance, e.g. five times. An example of a program that uses the **For...Next** loop is as follows:

     Sum, Average = 0
     FOR I = 1 to 5 DO
          Enter Number
          Sum = Sum + number
     NEXT I
     Average = Sum/5
     Display Sum, Average
     End

b. Repeat...Until Structure: This is a looping structure that repeatedly executes the loop body when the condition set is FALSE until it becomes TRUE. The number of repetitions may not be known in advance and the loop body is executed at least once. The syntax is as follows:

Repeat

Statement 1
Statement 2   loop body
....

Until {Condition}
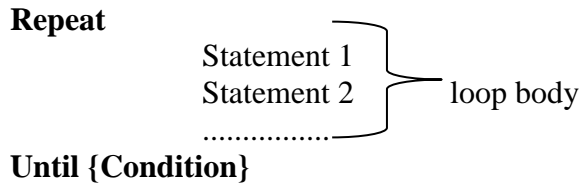
For example

Sum, Average, Count = 0
Repeat
    Enter Number (999 to end)
    Sum = Sum + Number
    Count = count + 1
Until Number = 999
Average = Sum / count
Print Sum, count, Average
End

In the above program:

- **Count** records the number of times the loop body executes.
- 999 is used to stop further data entry through the keyboard and thereby ending the loop. Such a value that stops further data entry through the keyboard thereby terminating a loop is called a **Rogue value or sentinel**.
- The condition here is {**Number = 999**}. The loop exits when the number 999 is entered. If 999 is part of the number to be entered in this program, then the user has to split it into two numbers, that is 999 = 990 + 9, therefore can be entered separately as 990 and 9.
- A flag is also used to control the loop. In this case 999 is also a flag.

NB. As for the Repeat...Until loop, the condition is tested after the loop body has been run at least once, even when the condition is true from start. This is rather misleading.

c. While ... Do Statement: A looping structure in which the loop body is repeatedly executed when the condition set is TRUE until it becomes FALSE. It is used when the number of repetitions is not known in advance. The condition set is tested first before execution of the loop body. Therefore the loop body may not be executed at all if the condition set is FALSE from start. The syntax of the WHILE…END WHILE structure is as follows:

WHILE {condition}
    Statement 1
    Statement 2   loop body
    ....
ENDWHILE
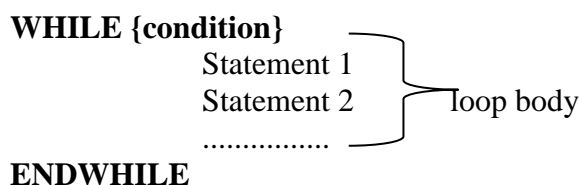
An example of the program is as follows:

Sum, Count, Average = 0
WHILE Count < 6 DO
    Enter Number
    Sum = Sum + number
    Count = count + 1
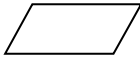*ENDWHILE*
Average = Sum/count
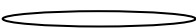*Display sum, count, average*
END

The word **WEND** can be used to replace the word **ENDWHILE** in some structures and therefore is acceptable. The word **Do, after the condition** is optional.

Differences between the Repeat...Until and the While…ENDWHILE structures

|	Repeat Until Loop	While Endwhile Loop
1	Loop body is executed when the condition set is FALSE until it becomes TRUE	Loop body is executed when the condition set is TRUE until it becomes FALSE
2	Loop body is executed at least once	Loop body may not be executed at all
3	Condition is tested well after execution of loop body	Condition is tested before execution of loop body

c. Flowcharts

It is a diagram used to give details on how programs and procedures are executed. Flowcharts are drawn using specific symbols, each with its own meaning, as given below:

Symbol	Explanation
Process Symbol	- Indicates where some form of processing occur
Arrow	-Shows directional flow of data (data flow symbol)
Input /output	- Parallelogram in shape. Indicates where data is entered and output form, either screen display or printout.
Terminal	- Oval in shape. Indicate the start and stop of a program. Therefore it is written either Start/Begin/Stop/End.
Connector	- Circular in shape. Denotes the start and end of a subroutine. Nothing should be written inside it.
Pre-defined process	Indicates a module/subprogram/procedure inside another program
Decision	Represents a selection stage. Often used where a condition is, especially in repetition and selection structures.

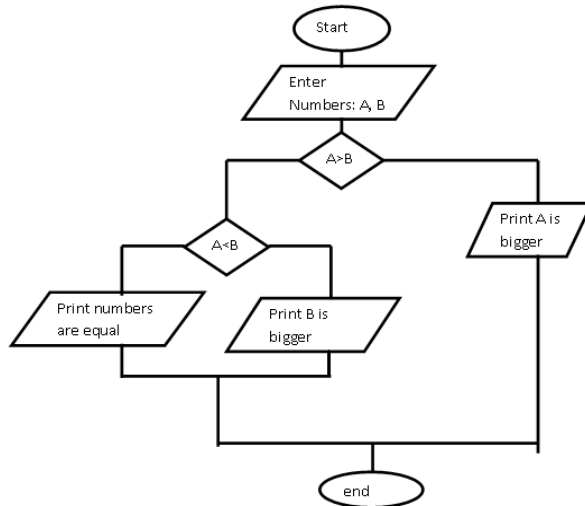**Illustrations of flowcharts for programs**
1. Using Simple Sequence Structure
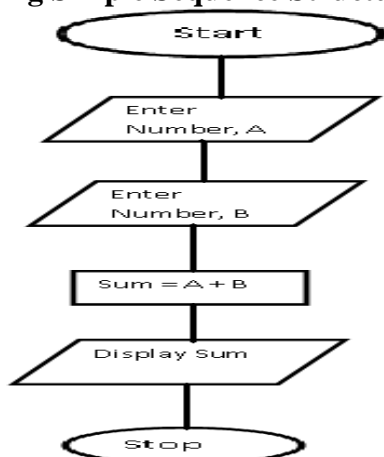
Start
Enter number, A
Enter number, B
Sum = A + B
Display Sum
Stop

Pseudocode for the flowchart on the left:

Flowchart equivalent to the pseudocode on the right
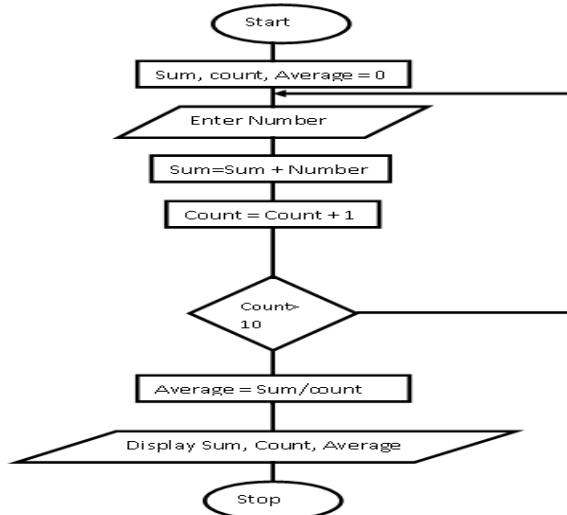
2. Using Selection Structure
Flowchart

Pseudocode equivalent

> Enter first Number, A
> Enter second number, B
> IF A>B THEN
>   Print A is bigger
> ELSE
> IF A<B THEN
>   Print B is bigger
> ELSE
>   Print Numbers are equal
> ENDIF
> ENDIF
> END

3. Using Iteration
(a) Repeat ... Until Structure
Flowchart

Pseudocode equivalent

Sum, Average, Count = 0
Repeat
Enter Number
Sum = Sum + Number
Count = count + 1
Until Count > 10
Average = Sum / count
Display Sum, count, Average
End

b) WHILE...WEND Structure and the FOR...TO...NEXT Loop
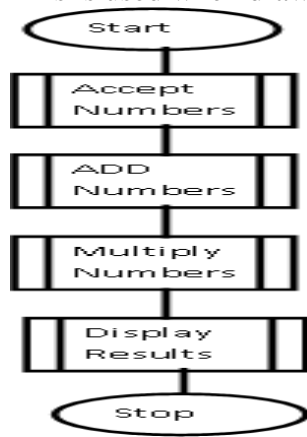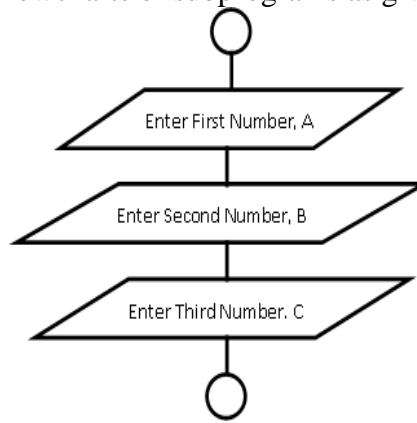
Flowchart
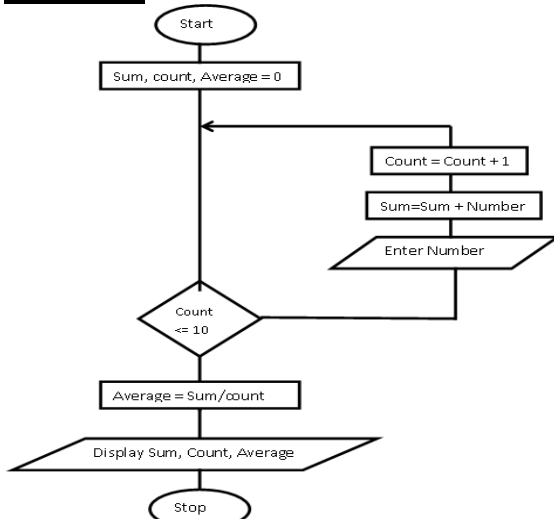
Pseudocode equivalent

Sum, Average, Count = 0
WHILE *Count <=10*
Enter Number
Sum = Sum + Number
Count = count + 1
WEND
Average = Sum / count
Display Sum, count, Average
END

Use of the Pre-defined Symbol and the connector

This is used when drawing flowcharts of subprograms as given below.

Start Module Accept Numbers
Enter First Number, A
Enter Second Number, B
Enter Third Number, C
End Module

a. Flowchart for whole program

b. Flowchart for module Accept Numbers

c. Pseudocode for module Accept Numbers

Flowchart (a) above indicates modules named Accept Numbers, Add numbers Multiply Numbers and Display Results. Flowcharts for individual modules can then be designed as given in diagram (b) above, only the first module is indicated. **Can you do the rest**?

d. Structure Diagrams: These are diagrams that show relationships between different modules as given below.
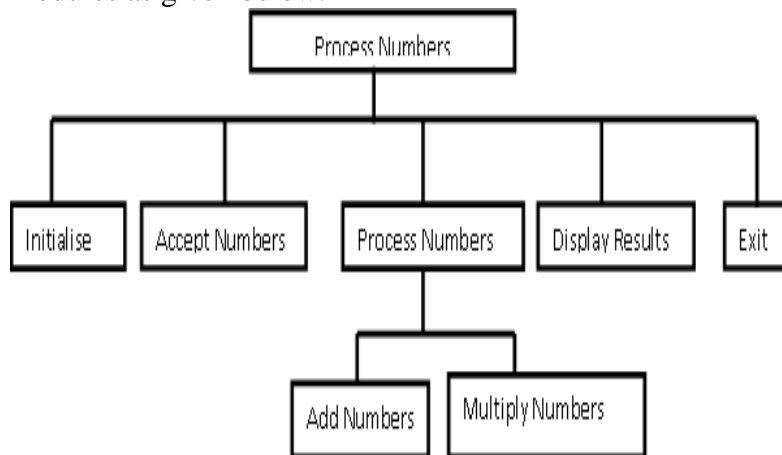
Start
Sum, Product = 0
Enter First Number, A
Enter Second Number, B
Sum = A + B
*Product = A * B*
Display Sum, Product
End

The structure diagram above indicates five sub-programs of the program Process Numbers, namely Initialise, Accept Numbers, Process Numbers, Display Results and Exit. The module Process Numbers has its own sub-programs, which are Add Numbers and Multiply Numbers. Modules are appropriate for very large programs. Can you write pseudocode for individual modules? The program can be written as a continuous single program as indicated on the right side of the diagram.

Interpreting and Testing Programs

Dry running (desk checking): the process of manually testing the logic of a program on paper before coding on the computer. Dry running is done to determine the logic of a program (to check if it gives intended results.)

Debugging: The process of finding and correcting errors in a program. Bugs are errors in a program. A debugger is a program used in aiding the finding and removal of errors in a program.

Programming Errors

Programming errors are grouped into:

i. Syntax error: this is an error of violating the grammatical rules governing sentence construction in a certain programming language, for example, leaving a semi-colon at the end of each line in Pascal. Syntax errors are detected by the computer. A program cannot run with syntax errors.

ii. Logic error (Semantic error): refers to an error in the sequencing of instructions, modules and specifying wrong formulae that will produce undesirable results. For example, instructing the computer to display result before any processing has been done. Logic errors cannot be detected by the computer. The user just finds wrong and unintended results of a process.

iii. Runtime (execution) error: These are errors that occur during program execution and can be generated when the computer tries to read past an end of file marker or by dividing a number by zero.

Data Testing

After a program has been coded, it must be tested with different data types to determine if intended results are produced. The types of test data that can be used include:

i. Extreme Data (boundary data/border line data): Refers to the minimum and the maximum values in a given range. For example, a computer program requires the user to enter any number from (between) 1 to 20. 1 and 20 are extreme data and the computer must accept these. Thus extreme data is accepted by the computer.

ii. Standard (normal) Data: This refers to data that lies within (in-between) a given range. In our example above, the numbers from 2 to 19 are standard data and are accepted by the computer.

iii. Abnormal Data: This refers to data outside a given range. As to our example above, the number 0, -1, -50 and all number from 21 and above are abnormal data. The computer system gives/displays an error message if abnormal data is entered.

Testing Strategies (Types)

First step involves testing of the programs and various modules individually, e.g.

- **Top-Down testing**: program is tested with limited functionality, starting from the complex problem, going to its smaller sub-problems. Most functions are replaced with stubs that contain code. Functions are gradually added to the program until the complete program is tested.

- **Bottom – up testing**: Each function is tested individually and then combined to test the complete program. Testing starts with the lowest, easiest modules, combining them and test as a more complex system until the whole system is tested.

-**Unit testing**: the process of testing each program unit (sub-routine/module in a suite) singly to determine if it produces expected results.

- **Integration Testing**: testing to see if modules can combine with each other and work as expected. The whole program is tested to determine if its module integrate perfectly

- **System testing**: the testing of the whole program after joining the modules to determine if it runs perfectly.

- **User acceptance testing**: determining if users of the new system are prepared to use it. Usually the final step. It enables identification of some bugs related to usability. User gain the confidence that the program being ushered meets their requirements

HUMAN – COMPUTER INTERFACES

Interface: A form of communication between the user and the computer, for example Graphical User Interface. It is the operating environment presented to the user by the computer system for interaction purposes. A program that is easy to learn and to use is said to be **user friendly.** A user friendly interface has the following **features**:

- It is easy for a user to start using the system, especially for beginners.
- The system should be self-contained so that users are not forced to access manuals.
- Minimum effort must be used for the user to complete required tasks.
- It should have minimum errors and unexpected results. Thus must be reliable.
- It should be logical and consistent, allowing the user to learn it faster.
- It is intuitive to use.
- Help is available.
- Can use menus, wizards, sound and colour to assist the user.

User friendly programs usually display windows, icons, menus, pointers and dialogue boxes.

An interface can contain the following:

- **Window**: - A rectangular area on the screen which displays text or images.
- **Icon**: - Small image on the screen that represent a file, folder, command or any object that can be manipulated by the user, like the **My Computer** icon on the desktop.
- **Menu**: - a list of options from which the user could select one.
- **Pointer**: - Arrow appearing on the screen that is moved by moving the mouse to point, select or open an icon.
- **Static Menu**: - Menu that appear on the screen most of the time, for example File, Edit, View, etc, which are found in Microsoft Word.
- **Pull Down Menu**: - a list of options that are listed going downwards.
- **Pop-up menu**: - A list of options that appear which you right click on an empty space on the screen.
- **Dialogue box**: - A rectangular area with many windows that prompts the user to provide data.
- **Prompt**: - a screen display that allows the user to enter a command by typing as in MS-DOS mode. A prompt may appear as C:>-
- **Cursor**: - a blinking arrow that shows an insertion point on the screen showing where text will appear when typing as in Microsoft Word.
- **Scroll bar**: - A vertical or horizontal bar that is moved up and down or left and right respectively, to view text on the screen.
- **Text box**: - In a dialog box, a box in which you type information needed to carry out a command. The text box may be blank or may contain text when the dialog box opens.

Types of User Interfaces

1. Graphical User Interface (GUI): It is a way of communication between the user and the computer by use of Windows, Icons, Menus and Pointers (WIMP) as supported by Microsoft Windows XP operating system. Programs that provide a graphical user interface include Microsoft Word 2003, Windows XP. The user moves a mouse and point on required options and then click. It has commands in form of icons which have the name of the command or file below the icon. The mouse is the most used device in this system. Suitable for users with lower computing skills

Advantages of GUI:

- It is faster to give/select commands by just clicking.
- It is easier for a novice (beginner) to use the system right away.

- It is user friendly (this is an interface that is easy to learn, understand and to use).
- There is no need for users to remember commands of the language.
- It avoids typing errors since no typing is involved.
- It is easier and faster for user to switch between programs and files.
- A novice (beginner) can use the system right away.

Disadvantages of GUI:
- The icons occupy a lot of disk storage space that might be used for storage of data.
- Occupy more main memory than command driven interfaces.
- Run slowly in complex graphics and when many windows are open.
- Irritate to use for simple tasks due to a greater number of operations needed.
- Usually only predefined choice are available.

2. Command Driven (Line) Interface / Character based Interface: This is an interface which allows the user to type the command to be carried out by the computer through the keyboard as supported by MS-DOS. Thus communication between the user and the computer is through typed commands. The command to be obeyed must be typed correctly; otherwise it will not be obeyed. Usually displays prompt; which are characters displayed on computer screen to let the user know that a command is required; e.g.

C:>_

This is the C-prompt, on the user can type the command in front, e.g.

C:>copy:\computernotes.doc D:\KapondeniT

The user has to remember the commands to be typed when performing a specific task. An example of a program that uses command driven interface is Microsoft Disk Operating System (MS-DOS). The commands are abbreviated and short e.g. Del (for delete), copy, print, etc.

Command Line interface is ideal for programmers and technically competent personnel.

Advantages of Command Driven Interface:
- It saves disk storage space since there are no icons involved.
- It is very fast in executing the commands given once the user mastered the commands.
- It saves time if the user knows the commands by heart.

Disadvantages of Command Driven Interface:
- It takes too long for the user to master all the commands by heart.
- It is less user friendly.
- Do not tolerate mistakes
- More suited to experienced users like programmers.
- Commands for different software packages are rarely the same and this will lead to mix-up of commands by the user.
- It is intimidating for normal computer users and beginners. Therefore is not the best for normal applications

3. Menu Driven Interface: This type of interface displays a list of options / commands from which the user has to choose one by use of the mouse or keyboard. Below is an illustration of a menu driven type of interface:

1. PRINT RECORD
2. DISPLAY RECORD
3. DELETE RECORD
4. EDIT RECORD
5. MY OPTION IS: __

The user has to enter 1, 2, 3 or 4 and then press enter on the keyboard.

Advantages of Menu Driven Interface:
- It is fast in carrying out task.
- The user does not need to remember the commands by heart.
- It is very easy to learn
- No need to consult manual

Disadvantages of Menu Driven Interface:
- The user is restricted to those few options available and thus is not flexible to use.
- The intended option can be a submenu, which may slow down operations

Characteristics of a Good User Interface
- Should have consistent menu structures
- **Forgiving**: should not be too strict as users can make mistakes. Thus should allow users to undo some actions.
- **Familiar**: should be similar especially for programs designed by the same company
- **Attractive**: Maybe by use of good colour, layout, etc
- **Efficient**: must perform functions faster and with less effort.
- Should be clear in terms of labelling and naming its use. Names should not be vague
- Should be legible

DATABASES

A Database is a collection of related and organised files sharable among computer users of an organisation. Databases enable addition, deletion and modification of data held in the computer.

Building Block of Computerised Databases

Bit

Byte

Field

Record

File
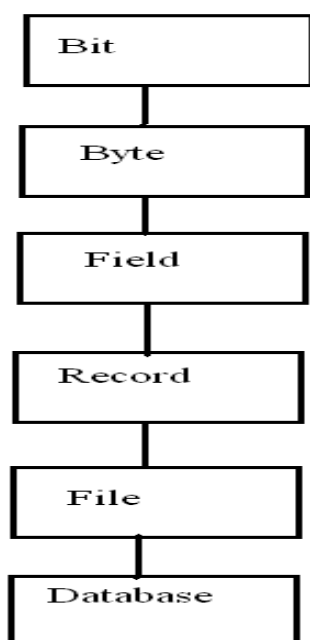
Database

- **Bit**: A single binary digit like 0 or 1.

- **Nibble**: A group of 4 bits, which is half a byte, eg 1001.

- **Byte**: A group of eight bits representing a character for example 10010110

- **Field**: A specific category of information in a table (database), for example Surname, Date of Birth, etc

- **Record**: A collection of related fields describing an entity, e.g patient.

- **File**: A collection of related records

- **Database**: A collection of related files

A database system (elements) is made up of stored data, software to maintain the database, procedures and the person working with the database.

Database Management System (DBMS)

It is a layer of software used to create, maintain the database and provides interface between the database and application programs. It allocates storage to data. The DBMS maintains data by: adding new records, deleting unwanted records, amending records.

The Database Administrator (DBA)

This is a person appointed to manage the database and ensures that the database meets the needs of the organisation. The DBA is supposed to have software and managerial skills. The **responsibilities** of the **DBA** are:
- Ensuring that the database meets the needs of the organisation.
- Setting up the database.
- Control, manage and maintain the database.
- Define, implement and control database storage.
- Ensure that policies and procedures are established.
- Guarantee effective production, control and use of data.
- Define the strategy of backup storage and recovering from system breakdown.
- Supervise amendments to the database.
- Ensures that the data is secure from unauthorised access.

Types Of Databases (Database Models)

These includes relational, hierarchical and network databases
1. Relational databases: These are database that organises data in a table format, consisting of related data in another file, allowing users to link the files together. Each

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column represents an attribute (characteristic or field). Each row represents a record (or tuple), as shown below.

Student Number	Surname	First Name	Date of Birth
0001/00	Kapondeni	Tungamirai	07/02/78
0028/05	Moyo	Cosmas	02/05/88
1255/05	Turugari	Tendai	04/06/97

Relational databases organise data in a flexible manner. They are also simple to construct and are easy to use. However, it may be difficult to come up with relationships.

From the above database structure, it can be noticed that:

- There are three records for Kapondeni, Turugari and Moyo. A record is also called a **tuple**.

- There are four fields: Student Number, Surname, First Name and Date of Birth.

- The student Number is used as a Primary Key (Key field) because it gives a unique(one) record. **A primary key** is a field that is used to identify a unique record from a database. All other fields from the above database are not appropriate for a key field because they can identify more than one record. That is surnames can be similar for 2 or more people as well as date of birth.

*NB: **Concatenated key**: the combination of two or more fields in a database in order to identify a unique record, e.g. using the Surname, First Name and Date of Birth in search of one record.

*NB: **Secondary Key**: A field used to identify more than one record at a time, e.g. a surname.

*NB: **Attribute**: A characteristic of a record, e.g. its surname, date of birth.

Entity: any object or event about which data can be collected, e.g. a patient, student, football match, etc.

Data types for fields can be:

- Numeric: consists of digits 0-9 only (negative or positive), 12, 900, -50, etc

- **Alphabetic**: Consists of letters of the alphabet (a-z, lowercase or uppercase) only, for example a person's name, like **Tungamirai**.

- Alphanumeric: Combination of digits and letters of the alphabet, eg. National Identification Number, like 27-134575-C-27

- Text: Combination of digits and letters of the alphabet.

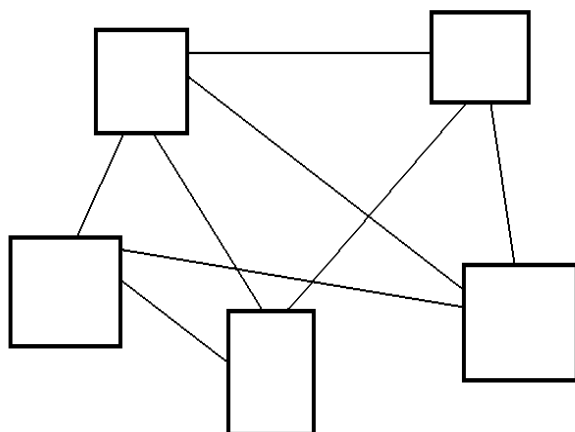**- String**: Combination of digits and letters of the alphabet. Same as text data type

- Currency: in monetary value, e.g. $10.00

- Date/time: shows date and time, e.g. 27/01/1997

- Array: An array is a series of elements of the same type placed in contiguous memory locations that can be individually referenced by adding an index to a unique identifier.

2. Network Databases

These databases have links that are used to express relationships between different data items.

Data is maintained by a single input.

There is little duplication of data.

There is no duplication of inputs. Linkages are more flexible.

Many to many relationships to records are limited

3. Hierarchical database: These are databases in which records are subordinates to other records in a tree structure of database. It promotes grandfather, father, and son relationship of records as illustrated below..
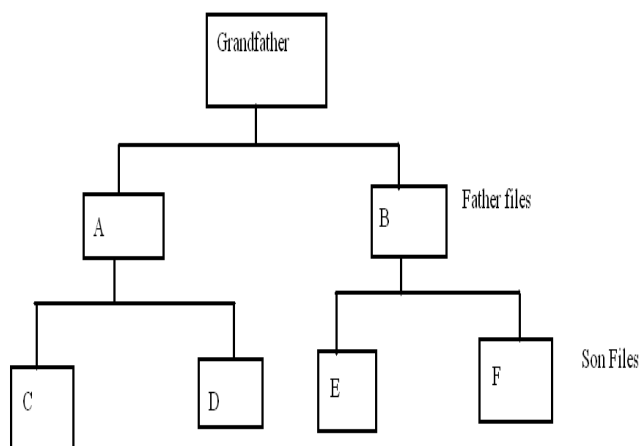
Each father file has one or more son files.

Each son file has only one father file.

There are no cross linkages of file records.

It is difficult to access all the files at one time.

A lot of duplication exists in this type of database structure

Advantages of Databases
- Validation checks are made on data during entry thereby reducing data entry errors.
- Searching and retrieval of data is very fast.
- Less likelihood of data getting lost.
- Record structure can be easily modified if the need arises.
- Files can be linked together making file updating easier and faster.
- Avoids/reduces data redundancy.
- Data can be secured from unauthorised access by use of passwords.
- Users can share data if the database is networked.
- Duplication of records is eliminated.
- Ad hoc reports can be created easily.
- Sorting of records in any order is very fast

Disadvantages of databases
- If the computer breaks down, you may not be able to access the data.
- It is costly to initially setup the database.

- Computer data can be easily copied illegally and therefore should be password protected.
- Takes time and costs to train users of the systems.
- Expensive to employ a database administrator who will manage the database

Advantages of computer based systems as compared to manual filing systems.
- Work can be done anywhere, even at offices in different countries.
- It is quicker to transfer files to other offices.
- Fewer staff is employed thereby saving expenses on wages.
- There are less chances of files getting lost.
- Less paperwork and storage requirements are needed.
- It is quicker to search needed records.
- It is quicker to sort records in any order using any field.
- It is quicker to cross reference files.
- It is quicker and easier to insert sections of files into reports

Flat file: this is a 2-dimensional file, comprising of rows and columns, that are used to store data, e.g. in a spread sheet. A flat file has the following weaknesses:
- Data is not sharable among users
- Too much duplication of records
- Too much data redundancy
- Difficult to manage

However, the introduction of the computer systems means that staff would need new skills, can lead to unemployment, people are likely to work from home, could lead to de-skilling and some health problems will suffice.

<u>**Sample Question**</u>
A database stores details about cars in a showroom: The database information can be amended, deleted or new ones inserted due to:
Amended: information in the databases is incorrect. Price of vehicle needs to be changed (e.g. sales). Change of vehicle colour.
Deleted (record deleted): **V**ehicle is sold or Vehicle is scrapped
Inserted/ added: new vehicle arrived. More information about current vehicle becomes known.

<u>**Coding Data Before Entry**</u>

Data to be entered into the computer can be coded / written in a short way, for example:
In databases, a field for sex can be coded as follows: **F** for Female, **M** for Female. In this case the user just enters F or M and not the whole field as it is. The column for colour can also be coded as B for Black, R for Red, Y for Yellow, etc.
Reasons form coding data:
- Codes are quicker to type in, both initially and subsequently.
- Reduces the size of files thereby saving disk storage space.
- Increases the speed of searching and any process performed on data

Features of Codes
- Should be of the same length.
- Must be easy to use.
- Must not be too short in case you will run out of codes.
- Codes are often unique

PERIPHERAL DEVICES CONTROL

A **peripheral** is any hardware connected to the central processing unit (processor), e.g. mouse, printer, etc. Peripherals can be controlled in a number of ways that will provide continuous job processing sequence. These include:

1. Buffers: This is a temporary memory store for data awaiting processing or output, compensating speed at which devices operate, for example printer buffer. Buffering is appropriate where an output device processes data slower than the processor. For example, the processor sends data to the printer, which prints much slower and the processor does not need to wait for the printer to finish printing in order for it to carry out the next task. The processor therefore saves the data, awaiting to be printed, in a buffer where it will be retrieved by the printer. Buffering usually match devices that work at different speeds, e.g. processor and disk.

Reasons for using printer buffers:
- ✓ Stores data or information being sent to the printer temporarily.
- ✓ Compensates for difference in speed of CPU and printer.
- ✓ Allows CPU to carry out other tasks whilst printer is printing.

Benefits of increasing size of buffer in a printer:
- ✓ Reduces the number of data transfers to the printer.
- ✓ Ensures a more efficient use of the CPU.
- ✓ Larger files can be sent to the printer without problems

2. Interrupts: An interrupts is a signal send to the processor by a peripheral for attention to be turned to that peripheral, thereby causing a break in the execution of a program, e.g. printer out of paper. Examples/types of interrupts include:
- ✓ **Input / output interrupt** e.g. disk full, printer out of paper, etc.
- ✓ **Arithmetic and Logic Unit error**.
- ✓ **Clock** (happens normally in time sharing systems where the clock transfers control from one computer to another.)
- ✓ **Program Interrupts:** Arithmetic overflow, division by zero, etc
- ✓ **Hardware Failure**: can be caused by power failure or memory parity error

If two devices interrupt the processor at the same time, interrupt priorities will be used. That is, an interrupt with a higher priority is handled first than that with a lower priority.

3. Polling: A process whereby the processor interrogates peripherals to determine if they are in a certain condition (or are present). Polling can take place during booting, where the processor checks the connected devices like keyboard, mouse, hard disks, etc. It also occurs in time-sharing systems where the processor checks if the terminal has anything that needs processing.

4. Spooling (Simultaneous Peripheral Operating On-line)
A process of transferring data from processor into temporary and faster access storage awaiting release to a slow output device, for example to a printer. Jobs from different users can be queued until the printer is ready to print. Involves use of queues when writing data to temporary storage.

5. Handshaking: It is the exchanging of signals to establish communication link between two devices/computers, for example modem and computer. It is a protocol for establishment of a link between two communicating devices. This controls movement of data between the computer devices, e.g. modems. The device engages in something like a

dialogue to acknowledge receipt of data. Can also be called **Three-Way Handshake** procedure

6. Scheduling: decides which jobs to run or processes first before others. This is whereby the processor decides the loading and execution of programs to provide continuous job processing sequence. Scheduling can do this by giving time slices to each computer or by queuing jobs. A number of scheduling algorithms can be used; e.g. Shortest Job First, Shortest Remaining Time, Round Robin, First Come First Served, etc. Scheduling generally ensures that:

- No resource is heavily under-utilised or over-utilised.
- The maximum number of interactive users get a reasonable response time.
- Making sure that no job is pushed to the back of a queue.
- Getting maximum number of jobs done in the minimum amount of time.

*NB: Directory: - a folder used to store other folders and files in a hierarchical structure. Directories are usually created in MS-DOS systems.

MALWARE

Malware (malicious software) is code or software that is specifically designed to damage, disrupt, steal or inflict some other "bad" or illegitimate action on data, hosts, or networks. They are parasitic programs, which are sometimes called Computer pests.

Types of Malware

Types of malware includes Worms, Trojan Horses and Viruses.

1. WORM

A malicious program capable of reproducing itself and spread from one computer to the next over a network and consume computer resources like memory and CPU. It does not delete files as viruses do. Worms travel unaided through the computer network. It does not require a host file or human assistance for it to spread.

2. Trojan Horses

These are malicious programs that appears as programs useful to the user with the intention of soliciting information like user accounts and passwords or damaging computer system files and desktop settings. It can also allow other users to access confidential information from your computer. They do not self-replicate.

3. Computer Viruses

A computer virus is a malicious program which attaches itself to computer file, replicates itself, damages, destroys or corrupts files and memory of the computer, for example, boot sector viruses. Computer viruses spread with human action, e.g. run an executable file. Viruses also need a host file to attach to it for it to spread. By replication, it means that the virus can multiply itself (produces several similar copies of itself) when it enters the computer system. Examples of known viruses are: Virus Melissa, Jerusalem, Cascade, etc.

Signs and symptoms of virus attack on a computer:
- Reduced system performance (reduced speed of operation).
- The computer displays nasty messages on the screen.
- The computer displays a blank screen.
- The computer system produces wrong results of a process.
- Unexplained and frequent loss of data held in the computer.
- The hard disk becomes inaccessible (the user cannot access data held in the computer).
- The computer fails to boot.

Effects of computer viruses:
- Memory of a computer will be used up, slows down computer.
- Alters system settings.
- Erases and corrupts files and data on the computer.
- Infects other computers on network.
- Leads to production loss.
- Leads to financial loss.
- The hard disk becomes inaccessible (the user cannot access data held in the computer).
- The computer fails to boot.
- The computer system produces wrong results of a process.

Methods by which viruses spread from one computer to another

- By sharing diskettes, compact disks, hard disks, memory sticks, memory cards, Video compact disks, Digital Versatile Disks, etc, with external users.
- Through networked computers, that is on a LAN, WAN or the internet.
- Can come as e-mail attachments, especially emails from unknown sources.
- Can come with downloads from bulletin boards

Methods of preventing virus attack on the computer
- Avoiding sharing external diskettes, compact disks, hard disks, memory sticks, memory cards, Video compact disks, Digital Versatile Disk.
- Installing firewall
- Install the latest antivirus program on the computer and upgrade it frequently.
- Scan the computer with the latest antivirus frequently.
- Avoid software distributed as shareware (freeware) (*software produced for distribution free of charge and can be distributed to others free of charge, e.g. computer games*).
- Avoiding downloading software from bulletin boards.
- Use disk free workstations.
- Do not open email attachments from unknown sources or download doubtful software from the Internet.
- Do not use files that come from unknown sources.
- Buy original software and do not buy pirated software.
- Disable compact disk drives, diskette drives and USB ports of the computer.

Antivirus programs
These are programs that detect computer viruses and reduce the risk of computers being attacked by viruses for example Norton Antivirus, MacAfee, Avira, Avast, AVG, etc.

Types of Computer Viruses
1. Boot sector Viruses
These viruses affect the booting sector on the hard disk so that the computer fails to boot.

2. File sector Viruses
These viruses destroy files that are created by users on the computer.

3. Direct Action Virus:

This type of virus only comes into action when the file containing the virus is executed.

4. Macro Virus

These attack macros in applications, e.g. in databases and spreadsheets. The most well-known macro virus is probably Melissa, a Word document supposedly containing the passwords to pornographic websites.

5. Multipartite Virus

A virus of this type may spread in multiple ways, and it may take different actions on an infected computer depending on variables, such as the operating system installed or the existence of certain files.

6. Polymorphic Virus

Another jack-of-all-trades, the Polymorphic virus actually mutates over time or after every execution, changing the code. Alternatively, or in addition, a Polymorphic virus may guard itself with an encryption algorithm that automatically alters itself when certain conditions are met.

7. Memory Resident Virus

This broad virus definition applies to any virus that inserts itself into a system's memory. It then may take any number of actions and run independently of the file that was originally infected.

Malware can be prevented using the following means:

- Use of audit trails to detect Trojan horses
- Backing up data to recover it after it has been destroyed or corrupted
- Use of antivirus programs
- Use of firewalls
- Use of anti-spyware. Spyware is a program that detects programs that run on the background without knowledge of user in order to steal data from the user, e.g. stealing passwords, account details, etc. Spyware is mostly used for the purposes of tracking and storing Internet users' movements on the Web and serving up pop-up ads to Internet users. Spyware does not self-replicate

DATA COMMUNICATION

This deals with the means of sending and receiving data on networked computers. Transmitted data can be in analogue or in digital form.
Digital Data: Data is in discrete value, that is, in ones and zeros.
Analogue Data: Data is in continuously varying form, in physical or original form e.g. human voice.

Synchronous and asynchronous Transmission
Synchronous Transmission: This is whereby data is sent in blocks (packets) at any given time. This method is faster in transmitting data.
Asynchronous Transmission: This is whereby data is send character by character over a transmission channel. This is much slower as compared to synchronous transmission.

Transmission Modes
Transmission modes include Simplex, Duplex (Full duplex) and Half Duplex

Simplex Transmission Mode
A

Half Duplex Transmission Mode
B

Duplex Transmission Mode
C
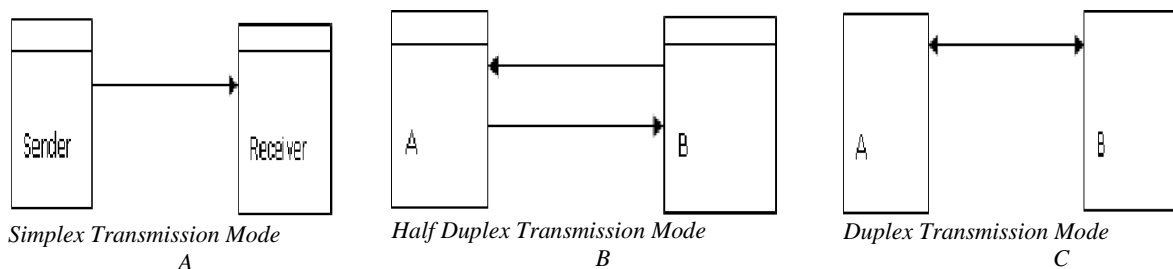
Simplex Mode: This is a mode of data transmission in which data travels only in one direction (uni-directional). Thus one computer acts as the sender and the other as a receiver forever. See diagram A, above.

Half Duplex: This is a transmission mode in which data travels in both directions but not simultaneously. It is bi-directional but not simultaneous. *See diagram B above*. The receiver waits until the sender has finished sending data in order for him to respond.

Duplex/Full Duplex: This is a transmission mode in which transmission is possible in both directions simultaneously. It is fully bi-directional. See diagram B above. There is no need for one to wait until the channel is free from data.

Transmission impairments

This refers to change in signal form as it propagates through the transmission channel. Transmission impairments include:

Attenuation: The loss of signal power as it moves through the transmission channel.

Noise: Occurs when an unwanted signal from other sources than the transmitter enters the transmission channel.

To avoid transmission errors, verification of data received can be done. Some of the verification methods employed in data communication are:

(a) Parity Checking

This is used in determining/verifying whether data has been correctly transmitted between computer devices or on a network. It uses parity bits to verify correctness of transmitted data.

- **Parity Bits: A parity bit** is an extra bit (1 or 0) that is appended to the left of a byte to make it even or odd depending on the method of parity checking being used. It is used in checking for errors in a group of bits transferred within or between computers. Parity bits are also used to determine if a block of data has been correctly transmitted over a communication channel. It works in the following way:
- **Using Odd Parity:** The letter C is transmitted as **1000011**. Since there are three 1s in this byte, a 0 is added to the left so that the total for 1s is odd, thus making it **01000011.** The first 0 (underlined) is used as the parity bit.
- **Using even parity:** In even parity, a 1 would be appended to the left of the byte so that the total number of ones is even, thus making it **1 1000011**

(b) Checksum: A verification check of adding together the digits in a block to give a number that will be transmitted together with the data. It is used to check whether errors have occurred in transmission or storage. Checksum can be either control total or hash total.

(i) Control Total: this is a meaningful total obtained by adding together all data in a table, e.g. prices of goods to give a total. If the total does not tally, then other elements may have been left out. This total is meaningful since it may be used to deduce if the organisation is making profit or not.

(ii) Hash Total: It is a meaningless total, obtained by adding together all digits in a field like **serial numbers** of a product to give a total that is used for validation purposes only. The total obtained is not, and cannot be used to deduce any other meaning. Thus in this case, the total obtained by adding product serial numbers cannot be used for any other purpose.

Multiplexing

This is a method of allowing multiple signals to share the same channel, reducing too much cabling, as shown below:

A multiplexer is used in multiplexing. A multiplexer is a device that joins two or more channels into one channel while the de-multiplexer is responsible for splitting a channel into a number of them for easy transmission to the intended destination.
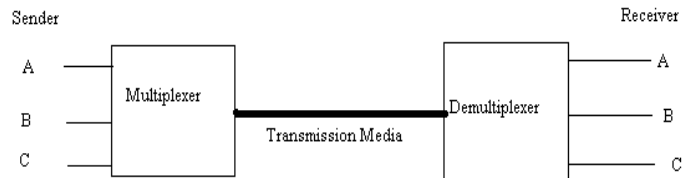
Bandwidth
Refers to the caring capacity of a transmission channel (measured in bits per second: bps). It determines the amount of data a channel can transmit at a given period of time.

Transmission Media
Refers to forms of media through which data is transferred from one point to another. These include:
1. Twisted Pair: These are cables with two copper wires of about 1 millimetre thick. The wires are twisted to avoid crosstalk. Twisted pair is very cheap to buy and offer good performance over short distances.
Disadvantages of twisted pair: Twisted pair is very cheap to buy. Has big attenuation. Has low bandwidth

2. Coaxial cable: It is a stiff copper wire surrounded by an insulating material. It has less attenuation than twisted pair, has high bandwidth and has low error rates. However, coaxial cable is expensive to buy and is stiff, making it difficult to handle.

3. Fibre optics: A media that uses light to transmit data. It has less attenuation, has very high bandwidth and cannot corrode (not affected by corrosion), it is thin and therefore has less weight. However, fibre optics is very expensive to buy and is uni-directional (travels in one direction only)

4. Infra-red waves: Refers to data transmission in form of waves as through some remote controls of televisions. It has enormous bandwidth. However, infrared waves do not travel through obstacles like buildings, they only work for very short distances, affect eyes and consume a lot of power.

5. Satellite transmission: These include earth stations which communicate with geostationary satellites (36 000 to 80 000 km above the earth. These have high bandwidth and support very long distance communication. However, they have big attenuation and are slow in sending messages.

DATA SECURITY AND INTEGRITY
1. Data Security
Data security refers to the means of protecting data from unauthorised access and from deliberate or accidental loss. It includes the safety of data from any form of hazard like floods, theft of the computer, fire, etc. Data security can be achieved by:

Physical Security measures against hardware and data loss.
- Locking the computer room.
- Employing security guards.
- Installing burglar bars on windows.
- Use of screen gates.

- Creating backups which will be stored at different locations (File Generations)
- Installing an electric fence around the computer room.
- Constructing a durawall around the computer room.
- Installing fire extinguishers inside the room.
- Building the computer room on higher grounds to avoid flooding.
- Installing a generator to avoid data loss through power cuts.
- Installing an **Uninterruptible Power Supply (UPS)** to prevent data loss through power cuts:

NB: a UPS is a device connected between a computer and a power source to ensure that electrical flow is not interrupted. UPS devices use batteries to keep the computer running for a period of time after a power failure. UPS devices usually provide protection against power surges and blackouts as well.

Measures against unauthorised access to data held in the computer:
- Use of data encryption methods before sending (*data encryption is the scrambling/coding of data before sending, for security reasons and can only be understood once decoded*).
- Use of user names and strong passwords.
- Use of firewalls.
- Biometrics: e.g. -use of iris, fingerprints and palm recognition systems.
- Log users for computer use.
- Use call back facility for incoming information.
- Check references of potential staff for employment purposes.
- Divide jobs between several people and then supervise the staff.
- Use physical locks like burglar bars, installing electric fences, etc.

2. Data integrity
This refers to the correctness and accurateness of data held in the computer. The issue of data integrity and security lead to the introduction of some data protection laws which govern how organisations holding public data must operate.

THE DATA PROTECTION ACT (1984)
This tries to regularise the use of automatically processed individual information by organisations. The Act outlines some of the following rules:
- Organisations using personal data must be registered.
- Data about individuals must be obtained fairly and lawfully for the purpose collected for.
- Data must be used only for the specific purpose collected for and may only be disclosed in accordance with such a purpose.
- Data collected must not be excessive for the purpose collected for but must be adequate and relevant.
- Data collected must be accurate, up-to-date and kept no longer than necessary.
- Data must be protected from unauthorised access or loss.
- Individuals with collected data have the right to view it and make alterations where necessary.

Implications of Computer Application

The following are some of the effects of use of computers (computerisation): de-skilling, electronic scabbing, new production methods, new products and services, health and safety, changes in working environment, unemployment, retraining

- Many people lose their jobs leading to high levels of unemployment.
- Huge profits are made by companies that engage in electronic commerce (*the advertising, buying and selling of goods and services on the internet*) and industrial automation.
- High productivity of high quality goods.
- Cheaper goods have been produced by companies.
- Cheaper, faster and more reliable means of communication have been realised.
- Creation of new jobs, e.g. computer programmers, computer technicians, etc.
- Companies lose a lot of money by re-training of their employees for them to catch up of software updates, software changes and hardware changes.
- **Retraining of workers** without computer knowledge for them to keep up with changing technology. A lot of money is invested in this exercise.
- **De-skilling**: - this is the replacement of skilled and semi-skilled labour by microprocessor controlled systems, with workers having to do jobs they did not train for, e.g. in manufacturing, for example in car assemblies. Most of the skills which were highly valued are taken to be useless by the introduction of computers. The ability of unions to maximise impact by selecting computing staff for strike action, etc.

*NB: - **Electronic scabbing**: a process whereby managers switch word-processing duties from striking workers in one country to none-striking workers in another country.

- Improved working conditions and environments for employees.
- Misuse of personal data held in public offices like police stations, registry offices, etc. **The data can be misused by:**

Hackers may **read** the data and pass it on. Hackers may **delete** the data. Hackers may **amend** the data, **plant viruses** in the computer system, engage in **industrial espionage**, **sell** company secrets and even **blackmail**.

Loss of data can be prevented by:

- Use of Usernames and strong Passwords.
- Do not connect the computers to a network. If connected to a network use dedicated lines.
- **Physical security** - locks on computer room doors and employ guards.
- Install Firewall.
- Use Proxy server security.
- Data can be encrypted.
- Use iris and palm recognition systems.
- Use of swipe cards, finger print recognition systems.
- **Use of audit trail**: The process that tracks the activities of users by recording selected types of events in the security log of a server or a workstation.

Computers can create health problems, for example:

1. **Repetitive Strain Injury (RSI):** - injury to muscles and tendons caused by continuous repetitive use of particular muscles, especially by using a keyboard, or working on an assembly line. Employees are advised to have **frequent breaks** to avoid RSI. They can also type with their fingers straight and flat on the keyboard.

2. **Eye problems**: - itchiness of eyes caused by light reflected by computer screens. This can be solved by:

Wearing spectacles (glasses). Use of antiglare screens: these reduce the amount of light reflected by the screen. Adjusting screen settings so that it becomes darker. Very bright colours are dangerous for eyes.

3. **Backbone problems**: sitting on the computer for a long period can cause this. This can be solved by:
Using a chair that is adjustable to fit the height suitable for each employee. Sitting up while using the computer.

4. **Obesity**: Most countries tend to have an obese population due to lack of exercises by computer users. This can be solved by exercising.

Social Problems

Children are being exposed to pornography, hate literature, racism and dangerous experiments like those for manufacturing bombs on the internet. **This can be solved by**:
Installing software that prevents children from accessing restricted sites on the internet like Net-Nanny, Surfwatch, Cybersitter, etc. This software blocks inappropriate sites and subject matter. Teachers and parents need to closely supervise students during internet access. Firewalls can also be installed as a security measure.

Protecting of data against accidental loss
- Periodically backing up data that will be stored in a secure, fireproof safe.
- Training users to follow proper updating procedures.
- Avoid bringing in outside disks which transmit viruses.
- Load recent antivirus programs and update them frequently.

JOBS IN THE COMPUTER INDUSTRY

IT personnel

The personnel/ jobs found in the computer industry includes the following:
- **Data capture clerk**:
  - ✓ Entering/typing data into the computer system.
  - ✓ Collection of data
  - ✓ Data preparation
  - ✓ Verification of data
- **Database Administrator**:
  - ✓ Manages the database of an organisation,
  - ✓ Ensures security of data in databases
  - ✓ allowing or controlling access to database,
  - ✓ updating the database
- **Hardware Technician**:
  - ✓ For troubleshooting hardware faults
  - ✓ Repairing of computer hardware like printers, replacing parts, etc.
  - ✓ maintenance of hardware
- **Network Technician**:
  - ✓ for troubleshooting the network
  - ✓ for network maintenance
  - ✓ upgrading the network
- **Network Administrator**:
  - ✓ giving access rights to the network
- **Systems Analyst**:

- ✓ Investigates information systems
- ✓ Identify system problems
- ✓ Carries out the cost-benefit analysis
- ✓ Recommends solutions to problems.
- ✓ Plans the development of the system
- ✓ Implements the system
- ✓ Test the developed system
- **Programmer**:
  - ✓ Designs computer programs
  - ✓ Coding of programs
  - ✓ test computer programs
  - ✓ debugging programs
  - ✓ write algorithms (flowcharts, pseudocodes , etc)
  - ✓ Produce user documentation
  - ✓ Produce technical documentation
- **IT Manager**: Manager information systems within an organisation
- **Computer Teacher/Lecturer**: teaches computer studies and computer sciences in schools, colleges and universities.