**Hardware** - Physical components that make up a computer system.

**Software** - Computer programs and related data that provide the instructions for telling computer hardware what to do and how to do it.

Hardware and Software have a symbiotic relationship, this means that without software hardware is very limited; and without hardware, software wouldn't be able to run at all. They need each other to fulfill their potential.

**Input and output Devices** - You should already have met the internal components of the computer and the peripherals that sit outside. We are now going to look at two different categories of peripherals. Those that **input** data into a computer, and those that **output** data from the computer.
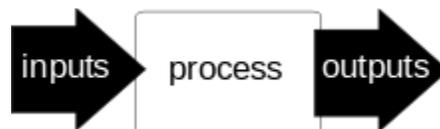


Computers work along the lines shown above, they receive inputs (instructions etc.), they process the input working out what to do with it, and then they output some form of result.

**Data Storage:** (Class Discussion)

| Component | Category | Access time | Capacity | Size | Cost |
|-----------|----------|-------------|----------|------|------|
| Register | Processor component | | | | |
| Cache memory | Primary storage | | | | |
| Main memory | | | | | |
| Hard disk | Secondary storage | | | | |
| Auxiliary storage | | | | | |

Figure 3.01 Trends in the factors affecting the choice of memory components

**Embedded System:** An embedded system is a computer system – a combination of a computer processor, computer memory, and I/O peripheral devices – that has a dedicated function within a large mechanical or electrical system.

An embedded system having processor, memory and I/O constructed on a chip is called a micro-controller. For some applications the system will have input and output solely associated with the internal workings of the host system. In other cases, perhaps when serving a monitoring or control function, there might be input from within the system but some output is provided to the user. Alternatively, the embedded system can provide a full user interface as, for example, in a **mobile phone.** These are made up of SRAM.

## Advantages:
1- Purposely built, usually performs only a single function.
2- Mass production brings cheaper circuits and less costly digital devices.

## Disadvantages:
1- Less memory space available to store programming instructions.
2- If errors were found after installation, whole production needs to be discarded.

## Memory Components:

| RAM | ROM |
|---|---|
| General data and instructions are in RAM. | Boot-up instructions are in ROM. |
| It can be repeatedly read from or written to. | It is read only memory. |
| It is volatile. | It is non-volatile. |

## Dynamic RAM:

1- It is made up of capacitors and need regular recharging to maintain the data.
2- It requires fewer electronic components.
3- It is cheaper to make and has high density for data storage.

## Static RAM:

1- It is constructed from flip-flops which continue to store data indefinitely.
2- It provides shorter access time.
3- Cache memory is usually provided by SRAM because of the faster access speed.

## Types of ROM:

1- In the simplest type of ROM, the programs or data are installed as part of the manufacturing process. If different contents are needed the chip must be replaced.
2- In Programmable ROM (PROM) the manufacturer of the chip supplies chips to a system builder. The system builder installs the program or data into the chips. This allows the system builder to test some samples of programmed chip before committing the whole

batch to be programmed. As with the simplest type of ROM, the program or data once installed cannot be changed.

3-  A more flexible type of ROM is Erasable PROM (EPROM). The installed data or program can be erased (using ultraviolet light) and new data or a new program can be installed. However, this reprogramming usually requires the chip to be removed from the circuit.

4-  The most flexible type of ROM is Electrically Erasable PROM (EEPROM). As the name suggests, this works in a similar way to EPROM, except an electrical signal can be used to remove existing data. This has the major advantage that the chip can remain in the circuit while the contents are changed. However, the chip is still used as read-only.

**Buffer:** A temporary storage created for data transmitted from one part of the system to another which functions as a queue.

Whenever data has to be transferred from one part of a computer system to another, a problem occurs if the data can be sent more quickly than it can be received. The solution to the problem is to use a buffer. Data enters a buffer before being transmitted to its destination. The buffer functions as a queue so the data emerges in the order that it has entered the buffer. Typically, the buffer is created in the computer memory.

**Transfer of Data, including Buffers and Interrupts -** There are two places where data can be stored in a computer system, the primary memory and secondary storage. Sometimes it is necessary to transfer data from the primary memory to secondary storage, perhaps because the computer is going to be switched off in which case the data in primary memory would be lost. Sometimes it is necessary to transfer from secondary storage to primary memory, perhaps because the processor wants to use some data held in the secondary storage and, consequently, needs to move the data into the primary memory first. Whichever direction the data is to be transferred the method of transfer must be planned.

This causes a problem. The primary memory operates at great speed because it is part of the processor, while the secondary storage is probably some sort of disk or tape which (while it seems incredibly quick to us) is very slow at reading or writing the data, in comparison. This means that the processor should be able to get on with something else because the secondary storage is so slow

## Secondary Storage Devices

**Magnetic Media** - Magnetic media stores data by assigning a magnetic charge to metal. This metal is then processed by a read head, which converts the charges into ones and zeros.

**Hard Disk** - Hard disks are usually found inside computers to store programs and data. They are increasingly cheap and more and more companies are using them to back things up. Hard disks can vary in physical size with some disks getting as small as your thumb. More closely packed platters, greater density of data on each platter to allow for more tracks and cylinders

and the ability to write smaller magnetics spots have all been developments in the design of hard disks to increase their storage capacity. The capacity of a commercial disk is currently up to about 4 terabytes allowing users to read and write to them.
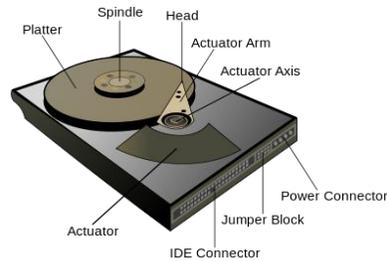


For the exam you must be able to explain how a hard disk works:

1. *The platters spin around the spindle*
2. *data is requested to be read from a particular area of a platter*
3. *the actuator arm moves the read head to that track*
4. *Once the data sector that is required has spun around and under the read head, data is read*
5. *Read data is sent from the IDE connector to main memory fahim*
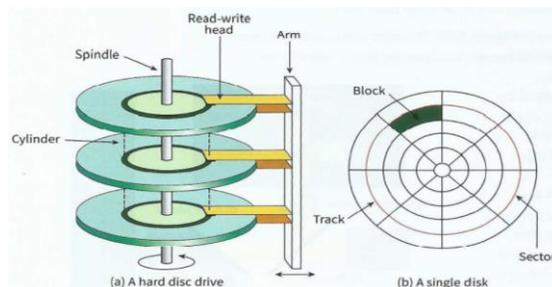


Description of a hard disk platter

Writing data is very similar:

1. The platters spin around the spindle
2. data is sent to the hard disk using the IDE connector
3. the actuator arm moves the write head to the track that will be written to
4. Once the data sector that is required has spun around and under the write head, data is written to the platter

## Pros

⊕ Fast seek times

⊕ Random access

⊕ High capacities possible

⊕ Low cost per megabyte

## Cons

⊖ Very susceptible to damage from physical shocks

**Magnetic Tape Drive** - Increasingly obsolete, the tape has been a medium to deliver software and back up data since the early days of computing. Nowadays they are used mostly for corporate backing up and archiving of data. Tapes are sequential data stores, meaning that if you had information stored at the end of the tape you would have to wind your way through the entirety of the tape before you could read it. There is no random access like with a hard disk! Tapes can be several terabytes in size and reading and writing can be very fast as long as you read or write continuous sections of the tape at once.

## Pros

⊕ Fast

⊕ High capacity

⊕ Cheap per megabyte

## Cons

⊖ Serial read and write capabilities

**Optical Media -** Optical media works by creating a disc with a pitted metallic surface. There are several different types of disk out there ranging from 650 MB to 128 GB, with the pits and lands getting closer together for higher volume disks. The principle behind how each of them works is the same.
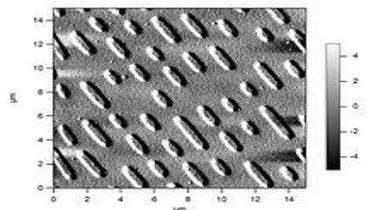
In the above figure, the pitted surface visible on the surface of a CD. Massively zoomed in!

## Optical Media

| Device | Type | Size | Image |
|---|---|---|---|
| • CD-ROM<br>• CD-R<br>• CD-RW | • Read Only<br>• Write once then Read only<br>• re-Writable | 650 - 900 MB | |
| • DVD-ROM<br>• DVD-R<br>• DVD-RW<br>• DVD-RAM | • Read Only<br>• Write once then Read only<br>• re-Writable<br>• re-Writable | 4.7 - 9.4 GB | |
| • Blu-ray (BD) disc<br>• HD DVD (obsolete) | Re-Writable and Read Only versions available. Uses a blue laser, that is able to recognise smaller pits and lands, which allows for the pits and lands to be more closely packed, and so store more data. | 25 - 128 GB | |
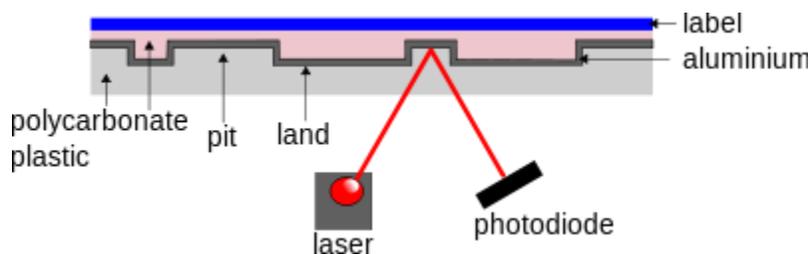
## CD ROM



A CD-ROM is a metal disc embedded into a plastic protective housing. Each disc has to be 'mastered'; this is the process of creating the CD and placing the data on it. CDs are WORM (Write Once, Read Many) media; this refers to the fact that once they have been mastered, there is no way to change the data on them.

## Reading from a CD-ROM

1. *A single track runs in a spiral pattern from the centre of the disc to the outside, this track is made of pits and lands to represent the ones and zeroes of binary data.*
2. *A low-powered laser is shone on the metallic surface and the reflection is captured in a photodiode sensor, the lands reflect differently to the pits, meaning it can tell the difference between a 1 and a 0*
3. *The disc spins and the laser follows the track*
4. *The binary data (the 1s and 0s) are put together and the CD-ROM has been read*

## Pros

⊕ Cheap

⊕ Data cannot be written over by the consumer

## Cons

⊖ Slow seek time

⊖ Data degrades with time, discs from 20 years ago might not work!

⊖ Can only be written to with a very high-powered laser, which is not usually available in-home computers

⊖ Data cannot be written over

**CD- R** - The CD-R is made of a reflective metal disk with a layer of (usually green, opaque) dye on top.

## Writing to a CD-R

1. *A single track runs in a spiral pattern from the centre of the disc to the outside.*
2. *A high-powered laser is shone onto the CD-R, changing the transparency (permanently) of the dye above. The transparent and opaque parts represent binary 1s and 0s*
3. *The disc spins and the laser follows the track, putting the binary data onto the CD-R in a spiral track*
4. *The data has been written.*

## Reading from a CD-R

1. *A single track runs in a spiral pattern from the centre of the disc to the outside, this track is made of pits and lands to represent the ones and zeroes of binary data*
2. *A low-powered laser is shone on the surface and the reflection is captured in a photodiode sensor. The opaque dye will reflect differently to the transparent dye (which would just reflect the metal underneath it), meaning it can tell the difference between a 1 and 0*
3. *The disc spins and the laser follows the track*
4. *The binary data (the 1s and 0s) are put together and the CD-R has been read*

## Pros

⊕ Cheap

⊕ Can be written to using a conventional home computer

## Cons

⊖ Slow seek time

⊖ Data degrades with time, discs from 20 years ago might not work!

⊖ Data cannot be written over

**CD- RW** - The CD-RW is made of a reflective metal disk with a layer of a special ('phase change') metal on top.

## Writing to a CD-RW

1. *A single track runs in a spiral pattern from the centre of the disc to the outside.*
2. *A high-powered laser is shone onto the CD-RW. Depending on whether this is very high powered or heats at a slightly lower temperature, the top layer of metal cools differently. These will result in different amounts of reflectivity, which represent the 1s and 0s.*
3. *The disc spins and the laser follows the track, putting the binary data onto the CD in a spiral track*
4. *The data has been written*

## Reading from a CD-RW

1. *A single track runs in a spiral pattern from the centre of the disc to the outside, this track is made of pits and lands to represent the ones and zeroes of binary data*
2. *A low-powered laser is shone on the surface and the reflection is captured in a photodiode sensor. The different ways the metal has cooled reflect different amounts, meaning it can tell the difference between a 1 and 0*
3. *The disc spins and the laser follows the track*
4. *The binary data (the 1s and 0s) are put together and the CD-RW has been read*

## Pros

⊕ Cheap

⊕ Can be written to using a conventional home computer

## Cons

⊖ Slow seek time

⊖ Data degrades with time, discs from 20 years ago might not work!

⊖ Data can be changed after writing

⊖ Not all CD players (mostly older ones) can read CD-RWs, as opposed to CD-ROMs and CD-Rs

| CD (Compact Disc) | DVD (Digital Versatile Disc) | Blu Ray |
|---|---|---|
| Red laser is used | Red laser is used | Blue laser is used |
| Single polycarbonate layer is used. | Double polycarbonate layer is used. | Single polycarbonate layer is used. |
| Wavelength of laser light is 780nm. | Wavelength of laser light is 650nm. | Wavelength of laser light is 405nm. |

**DVD-RAM:** It is different from conventional CD/DVD is that it uses concentric tracks instead of spiral track. The concentric track enables simultaneous read and write operations. They have more longevity and make them ideal for archiving.

## Solid-State Memory

| Device | Description |
|---|---|
| USB flash drive | Up to 256 GB |
| Memory card | Up to 256 GB |

The basis for this is 'flash' memory, which is a semiconductor technology with no moving parts. The circuits consist of arrays of transistors acting as memory cells. The most frequently used technology is called 'NAND' because the basic circuitry resembles that of a NAND logic gate. The most frequent use is either in a memory card or in a USB flash drive (memory stick). In the latter case the flash memory is incorporated in a device with the memory chip connected to a standard USB connector.

## Virtual Reality Headset

The most important components of a virtual reality headset are the two eye-pieces. These are fed paired images from the controlling system which, when looked at together, give the eyes the sensation of being in a 3D environment. The images can be collected using specialized photographic techniques or can be created using a 3D graphics package. The wearer of the headset can control w hich part of the 3D environment is in view. They do this by moving their head or by using a controlling device. Virtual reality (VR) headsets are widely used with video games but they are also used in other applications, including simulators and trainers.

## Hardware Devices:

## Laser Printer

A schematic diagram of the workings of a laser printer is shown in Figure. The operation can be summarized as follows.

1. The drum is given an electric charge.
2. The drum starts to revolve step by step.
3. At each step a laser beam is directed by the mirror and lens assembly to a sequence of positions across the width of the drum.
4. At each position the laser is either switched off to leave the charge on the drum or switched on to discharge the position.
5. This process repeats until a full-page electrostatic image has been created.
6. The drum is coated with a charged toner that only sticks to positions where the drum has been discharged.
7. The drum rolls over a sheet of paper which is initially given an electric charge.

8. The sheet of paper is discharged and then is passed through heated rollers to fuse the. toner particles and seal the image on the paper surface.
9. The drum is discharged before the process starts again for the next page.
   The above sequence represents black and white printing.
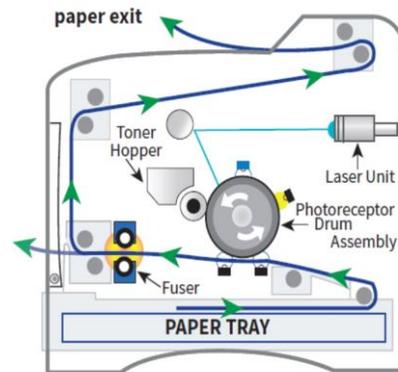


**3-D PRINTERS:** It is based on inkjet or laser printer technology but builds a 3-D object layer by layer using material such as powdered metal, paper or ceramic.

## USES:

a- Prosthetic limbs can be made to fit exactly on to the injured body.
b- Used in precise reconstruction surgery i.e. facial reconstruction.
c- Aerospace manufacturing.
d- Fashion and art 3-D printing.
e- Manufacturing industry.

## HOW 3-D PRINTER WORKS:

1- A design is made using CAD.
2- The design is imported into a special software from where 3-D printer can understands the design.
3- The 3-D printer is set up to allow the solid object to be made.
4- The object is built up layer by layer.
5- The object is removed from the printer and is then may be given final touch by hand sometimes.

## Advantages:

a- Customized products can be manufactured.
b- It manufactures accurate, precise and relatively quickly.
c- It produces artificial limbs.
d- It saves labor cost.

### Disadvantages:

**a-** Expensive.

**b-** In the hands of wrong people can lead to dangerous and illegal activities.

**c-** People can lose jobs due its commercial use.


## Touch – Sensitive Screen

1. *Each of the four corners of a screen emits a uniform electric field which covers the screen*
2. *When you place your finger on or near the screen it disrupts this field and draws current*
3. *Measuring the amount of current pulled from each corner you can triangulate the position of the finger.*
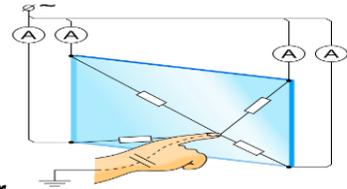
**Capacitive Touch Screen:** This is made up of many layers of glass that act like a capacitor, creating electric fields between the glass plates in layers. When the top glass layer is touched, the electric current changes and the coordinates where the screen was touched is determined by an on-board processor.

**Resistive Touch Screen:** This makes use of upper layer of polyester and a bottom layer of glass. When the top polyester layer is touched, the top layer and the bottom layer complete a circuit. Signals are then sent out which are interpreted by a microprocessor, the calculations determined the coordinates of where the screen was touched.

## Pros

⊕ Natural, intuitive interface with devices.

⊕ The ability to remap screen functions to suit the task (for example bringing up a keyboard when necessary.

## Cons

⊖ Cold weather can affect the functioning of touch screens.

⊖ Won't work through standard gloves, as this stops your fingers conducting electricity.

## Microphone:

This is a device that has a diaphragm, a flexible material that is caused to vibrate by an incoming sound. If the diaphragm is connected to suitable circuitry the vibration causes a change in an electrical signal. A condenser microphone uses capacitance change as the mechanism; an alternative is to use a piezoelectric crystal. The analogue electrical signal is converted to a digital signal by an analogue-to-digital (ADC) converter so that it can be processed inside the computer.

For output, a speaker (loudspeaker) is needed. How this works is effectively the reverse process to that for input. Digital data from the computer system is converted to analogue by a digital-to-analogue (DAC) converter. The analogue signal is fed as a varying electrical current to the speaker. In most speakers, the current flows through a coil suspended within the magnetic field provided by a permanent magnet in the speaker. As the size and direction of the current keep changing, the coil moves backwards and forwards. This movement controls the movement of a diaphragm, which causes sound to be created.

**Sensors** - A **sensor** is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output.

## Types

- Pressure sensor
- Ultrasonic sensor
- Humidity Sensor
- Gas Sensor
- PIR Motion Sensor
- Acceleration sensor
- Displacement sensor

## Actuators:

An **actuator** is a type of motor that is responsible for moving or controlling a mechanism or system. They are devices which transform an input signal (mainly an electrical signal) into motion.

**Hydraulic -** A hydraulic actuator consists of cylinder or fluid motor that uses hydraulic power to facilitate mechanical operation

**Electric** - An electric actuator is powered by a motor that converts electrical energy into mechanical torque.

**Mechanical** - A mechanical actuator functions by converting rotary motion into linear motion to execute movement.