









Syllabus Content:

3.1 Computer and their components

-  Show understanding of the need for input, output, primary memory and secondary (including removable storage)
-  Show understanding of embedded systems including its benefits and drawbacks
-  Describe the principal operations of hardware devices including:
 - microphone
 - speakers
 - touch screen
 - magnetic hard disk
 - solid state (flash) memory
 - optical discs reader/writer
 - laser printer
 - 3D printer
 - Virtual Headset
-  Show understanding of the use of buffers Including their use in a range of devices and systems
-  Explain the differences between Random Access Memory (RAM) and Read Only Memory (ROM)
-  Explain the differences between Static RAM (SRAM) and Dynamic RAM (DRAM)
-  Explain the difference between Programmable ROM (PROM), Erasable Programmable ROM (EPROM) and Electrically Erasable Programmable ROM (EEPROM)
-  Show an understanding of monitoring and control systems Including:
 - difference between monitoring and control
 - use of sensors (including temperature, pressure, infra-red, sound) and actuators
 - importance of feedback

Input, output and storage devices

Computer System:

A computer is an electronic machine that accepts data, stores and processes data into information. The computer is able to work because there are instructions in its memory directing it, instructions that direct the computer are called **software** or **computer program**. The physical parts of the computer that you can see and touch, such as the keyboard, monitor and the mouse are called **hardware**. There are four major categories of computer hardware:

1. **Input devices:** used to enter data into the computer
2. **Processing devices:** manipulate the data.

3. **Storage devices:** store data and program.
4. **Output device:** show results of the process.






Embedded systems

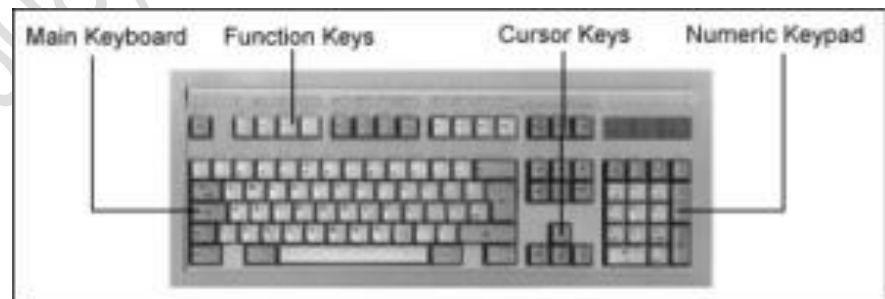
Much of the hardware in Section 3.01 relates to what we can call a general-purpose computer system. We also need to consider embedded computer systems because there are many more of these systems in use than there are general-purpose systems. Any manufactured item that has mechanical or electrical parts will almost certainly contain one or more embedded systems.

An embedded system must still contain a processor, memory and an I/O capability. If these are constructed on one chip this is called a microcontroller. 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.

Input devices:

An input device is any hardware component that allows you the user to enter data or instruction into the computer. There are many manual/automatic input devices. Most widely used input devices are:

-  Keyboard
-  Pointing devices
-  Tracker ball mouse
-  Laser mouse
-  2D, 3D Scanners



Touch Screen




A touch screen is an alternative to a separate pointing device. With a touch screen the user selects items on the screen by touching the surface. This makes touch screen systems very intuitive and simple to use.

Often used for information terminals in public places e.g. libraries or museums where mice or keyboards may be stolen or damaged.



They allow simple touch to launch an application or to carry out many of the functions of pointing devices such as a mouse. One of the main uses of touchscreen technology is in mobile phones.

At present, there are three major types of touchscreen technologies applied to mobile phone screens:

-  Capacitive
-  Infra-red
-  Resistive.

We will consider how each of these technologies work and what their main benefits and drawbacks are.

RESISTIVE

- This makes use of an upper layer of polyester (a form of plastic) 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 determine the coordinates of where the screen was touched.

Benefits

- It is relatively inexpensive technology.
- It is possible to use bare fingers, gloved fingers or a stylus to carry out an input operation.

Drawbacks

- Screen visibility is poor in strong sunlight.
- It doesn't permit multi-touch capability.
- The screen durability is only fair; it is vulnerable to scratches and the screen wears out through time.

CAPACITIVE

- 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 microprocessor.

Benefits

- This is a medium cost technology.
- Screen visibility is good even in strong sunlight.
- It permits multi-touch capability.
- The screen is very durable; it takes a major impact to break the glass.

Drawbacks

- Allows only the use of bare fingers as the form of input; although the latest screens permit a special stylus to be used.

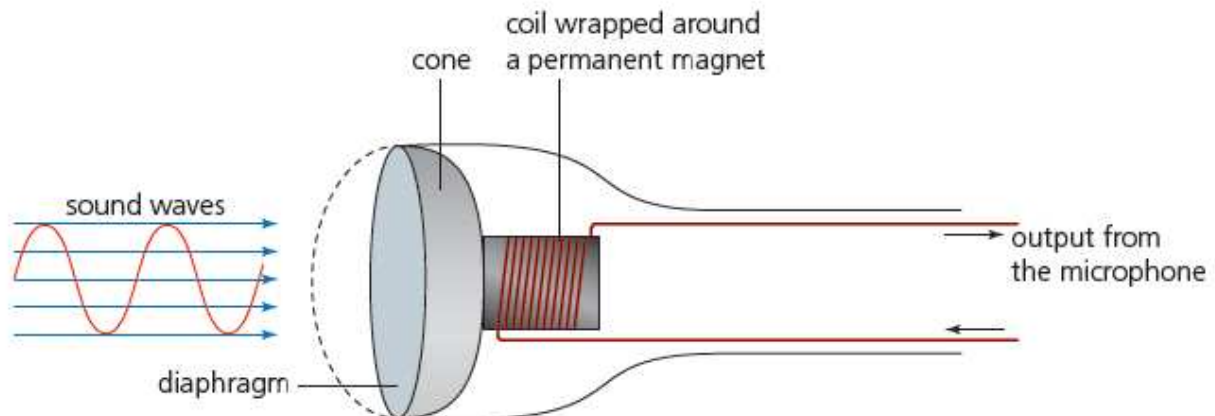
Microphone

An input device that converts **sound** into a signal that can be fed into a computer.

The signal from a microphone is usually **analogue** so, before it can be processed by a computer, it must be converted into digital data. An [Analogue-to-Digital Converter \(ADC\)](#) is used for this (usually built into the computer's sound card)



Many headphones now come with microphones to allow them to be used with chat and phone applications



- When sound waves hit the diaphragm of microphone, it cause it to vibrate.
- A copper coil wrapped around the permanent magnet is connected to diaphragm. When diaphragm vibrates, copper coil also moves back and forth causing magnetic field around permanent magnet.
- The disturbance of magnetic field around permanent induces electrical current.
- The electrical signals are sent to ADC and then sent to computer in digital format.

Output devices

An output device is a piece of hardware that is used to display or output data which has

Printer:

Printer is an output device that prints character and graphics on paper or other materials.

Laser Printer:

LASER PRINTERS differ greatly from inkjet printers in the way they print pages. They use dry powder ink rather than liquid ink and make use of the properties of static electricity to produce the text and images. Unlike inkjet printers, laser printers print the whole page in one go (inkjet printers print the page line by line).

The following steps describes briefly the stages that occur when a document is printed using a laser printer:

1. Laser printer uses a laser scanning a drum to print with powdered ink, known as toner.
2. The printer places an even, negative, static charge on a photoconductive drum.
3. It scans a very narrow laser beam across the surface of the rotating drum.
4. The laser beam causes the negative charge to leak away wherever it shines on the drum.
5. The drum revolves past a supply of toner which is also charged negatively. The toner is attracted onto those regions of the drums surface where no charge remains.
6. Toner particles are repelled by those regions that remain charged because **they were not lit by the laser's beam**.
7. **The printer rapidly switches the beam on and off** to draw the required pattern of output.
8. A roller presses a sheet of paper against the rotating drum and the toner particles are attracted to the **positively charged paper with greater force** due to laws of physics.
9. Another roller **presses the paper against a heated 'fuser' roller. The heated toner melts and bonds to the paper**, producing a printed copy.
10. If there are four drums with four different colors of toner the printer can print in color.

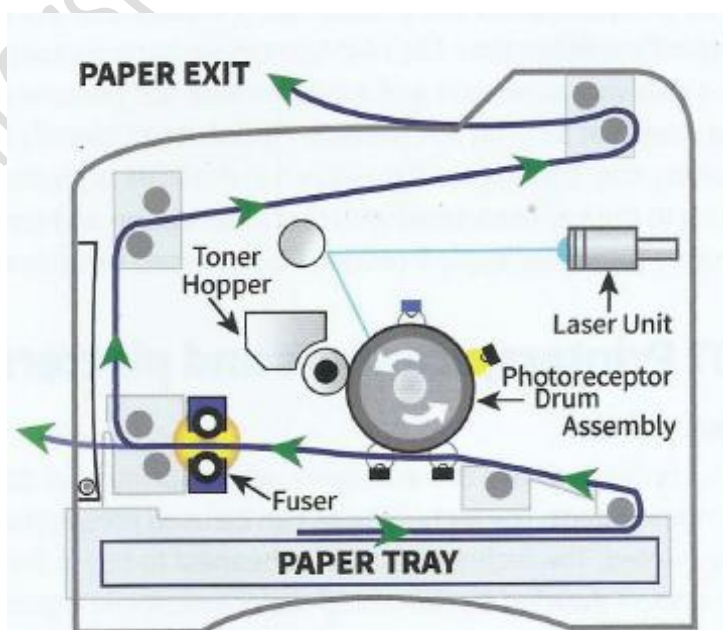


Figure 3.06 A schematic diagram of a laser printer



Inkjet printer

An inkjet printer uses a print head to propel differently sized droplets of ink, measuring just Pico liters, from a number of fine nozzles onto a sheet of paper. The printhead scans from side to side on stabilizer bar and rollers feed the paper forward.

1	The data from the document is sent to a printer driver
2	The printer driver ensures that the data is in a format that the chosen printer can understand
3	A check is made by the printer driver to ensure that the chosen printer is available to print (e.g. is it busy, is it off line, is it out of ink, and so on)
4	The data is then sent to the printer and it is stored in a temporary memory known as a printer buffer (see Section 4.3)
5	A sheet of paper is then fed into the main body of the printer; a sensor detects whether paper is available in the paper feed tray – if it is out of paper (or the paper is jammed) then an error message is sent back to the computer
6	As the sheet of paper is fed through the printer, the print head moves from side to side across the paper printing the text or image; the four ink colours are sprayed in their exact amounts to produce the desired final colour
7	At the end of each full pass of the print head, the paper is advanced very slightly to allow the next line to be printed; this continues until the whole page has been printed
8	If there is more data in the printer buffer, then the whole process from stage 5 is repeated until the buffer is finally empty

Speakers:

Speakers are one of the most common output devices used with computer systems. The purpose of speakers is to produce audio output that can be heard by the listener.

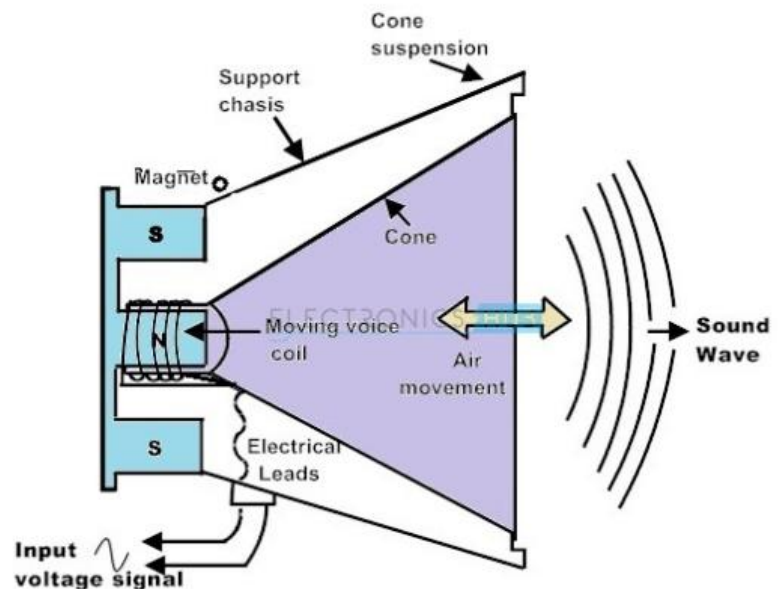
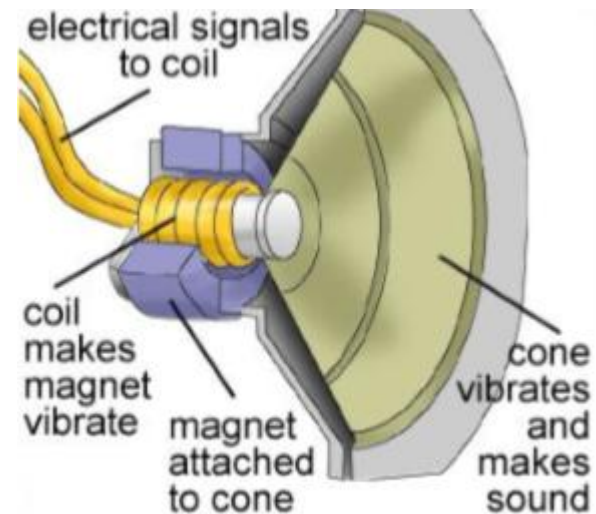
Speakers are transducers that convert electromagnetic waves into sound waves. Speakers use magnets to convert electricity into sound waves. This is a basic principle of physics.

Sound is made when an object makes the particles around it vibrate. These vibrations travel through the air, and reach your ears. Our brain interprets this motion as sound. High frequencies of sound are made when the wavelength of the vibrations are close together. Low frequencies occur when they are farther apart. The amplitude of the vibrations causes the level of volume you hear.

To make these vibrations, speakers have a set of magnets. One of them is called the permanent magnet. It **doesn't move or change polarity and is made of a magnetic metal like iron. The other magnet is an electromagnet.**

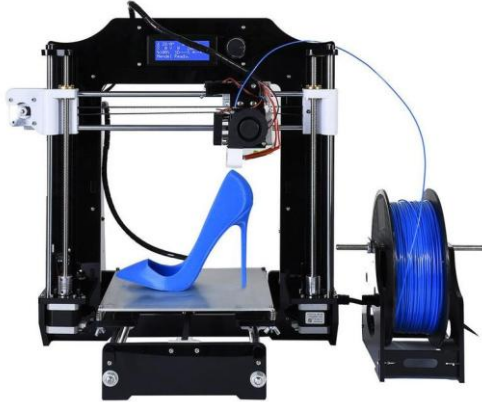
It is a coil of metal wire like copper or aluminum. When an electric current is sent through the electromagnet, it is either attracted to or repelled away from the permanent magnet.

The polarity of the coil can be reversed depending on the current. This back and forth movement causes the diaphragm or cone to vibrate, because it is connected to the magnetic coil. This is the sound that you hear.



3D- Printers:

3D PRINTERS are primarily used in COMPUTER-AIDED DESIGN (CAD) applications. They can produce solid objects which actually work. The solid object is built up layer by layer using materials such as powdered resin, powdered metal, paper or ceramic powder.



The motorcycle was made using an industrial 3D printer.



It was made from many layers (0.1 mm thick) of powdered metal using a technology known as BINDER 3D PRINTING.

The following describes some of the features of 3D printing:

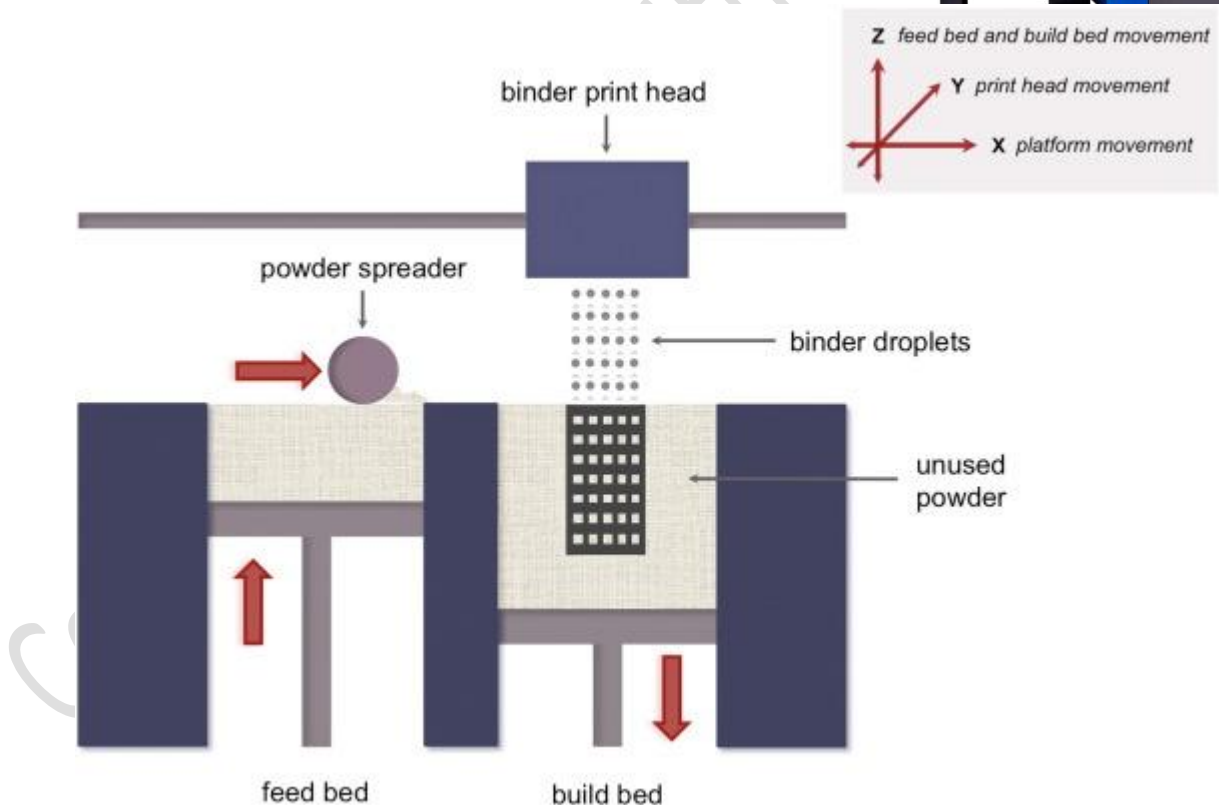
Various types of 3D printers exist; they range from the size of a microwave oven up to the size of a small car.



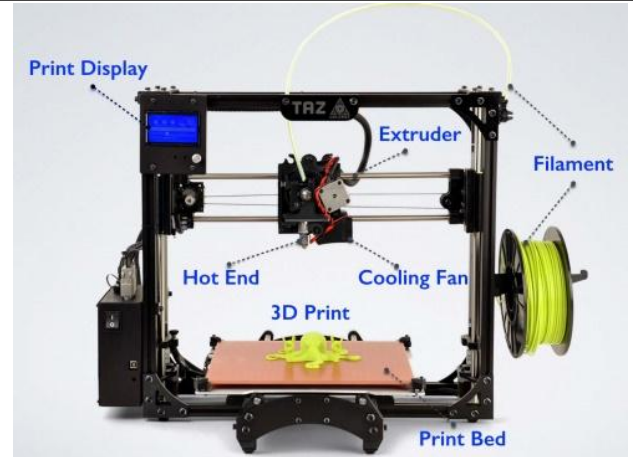
3D printers use ADDITIVE manufacturing (i.e. the object is built up layer by layer); this is in sharp contrast to the more traditional method of SUBTRACTIVE manufacturing (i.e. removal of material to make the object). For example, making a statue using a 3D printer would involve building it up layer by layer using powdered stone until the final object was formed.

The subtractive method would involve carving the statue out of solid stone (i.e. removing the stone not required) until the final item was produced. Similarly, CNC machining removes metal to form an object; 3

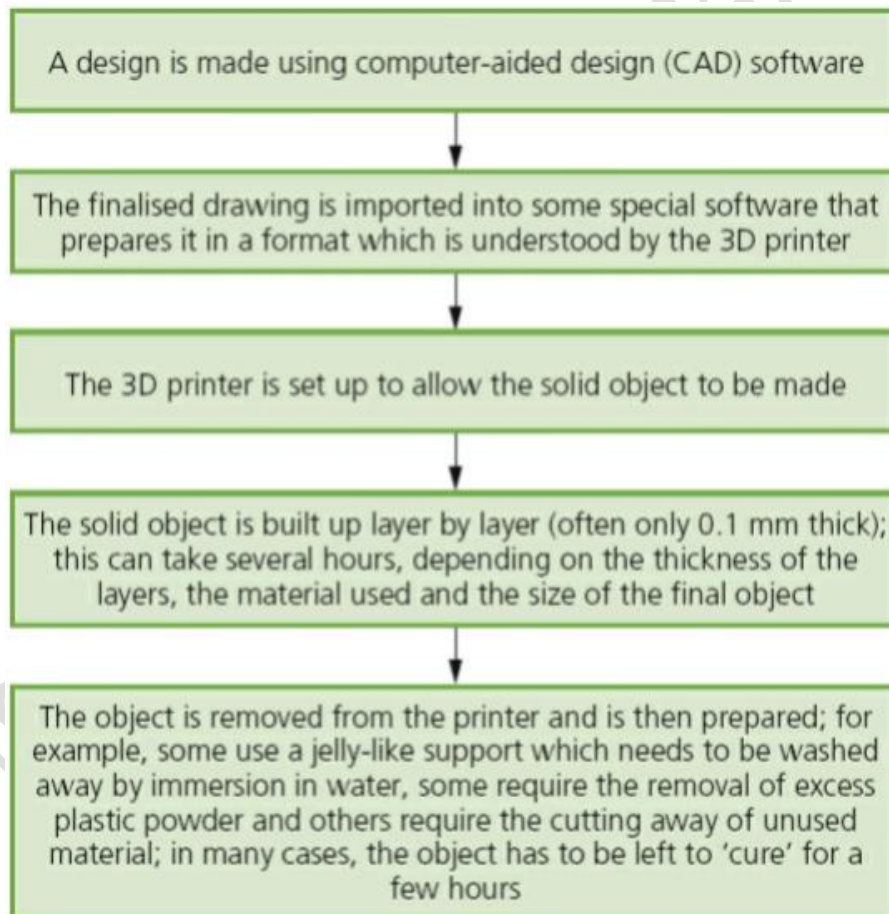
- 3D printing would produce the same item by building up the object from layers of powdered metal.
- Direct 3D printing uses inkjet technology; a print head can move left to right as in a normal printer. However, the print head can also move up and down to build up the layers of an object.
- Binder 3D printing is similar to direct 3D printing. However, this method uses two passes for each of the layers; the first pass sprays dry powder and then on the second pass a binder (a type of glue) is sprayed to form a solid layer.



- Newer technologies are using lasers and UV light to harden liquid polymers; this further increases the diversity of products which can be made.



How to create a solid object using a 3D printer There are a number of steps in the process of producing an object using these 3D printers. The steps are summarised below



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 specialised photographic techniques or can be created using a 3D graphics package. The wearer of the headset can control which part of the 3D environment is in view. They do this by moving their head or by using a controlling device.



Embedded systems

Embedded systems involve installing microprocessors into devices to enable operations to be controlled in a more efficient way. Devices such as cookers, refrigerators and central heating systems can now all be activated by a web-enabled device (such as a mobile phone or tablet). The time a central heating system switches on or off and the temperature can all be set from an app on a mobile phone from anywhere in the world.

There are pros and cons of devices being controlled in this manner, as shown in [Table 3.3](#).

Pros of embedded systems	Cons of embedded systems
<ul style="list-style-type: none"> • small in size and therefore easy to fit into devices • relatively low cost to make • usually dedicated to one task, making for simple interfaces and often no requirement of an operating system • consume very little power • very fast reaction to changing input (operate in real time) • with mass production comes reliability 	<ul style="list-style-type: none"> • difficult to upgrade devices to take advantage of new technology • troubleshooting faults in the device becomes a specialist task • although the interface can appear to be simple, in reality it can be more confusing (changing the time on a cooker clock can require several steps, for example) • any device that can be accessed over the internet is also open to hackers, viruses, and so on • due to the difficulty in upgrading and fault finding, devices are often just thrown away rather than being repaired (wasteful)

Backing storage:

Backing storage (also called auxiliary storage) stores programs and data for future use. In order to store data while the electricity is switched off or unavailable storage must be non-volatile. Access to backing storage is slower than internal memory. Operating

systems and program files are loaded into RAM from backing storage when required for execution.

It is important to distinguish between a storage device and storage medium. The storage device is the machine that stores data; the storage medium is the material on which the device stores data. There are three different types of backing storage device:

1. Magnetic storage device
2. Optical storage device
3. Solid state storage device.

Magnetic Storage device:

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. Historically, magnetic media has been very popular for storing programs, data, and making backups. It looks set to continue in this role for some time. However, solid state technology is starting to be used more and more, storing programs and data on new devices such as mobile phones and cameras.

Hard Disk Drive (HDD)

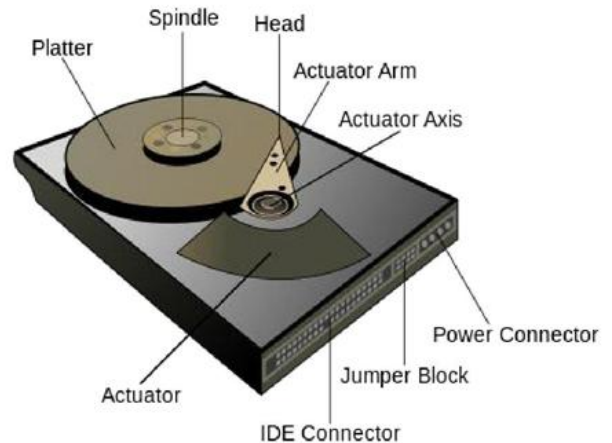
Hard disks are usually found inside computers to store programs and data. They are increasingly cheap and more and more companies are using them to back things up. Hard disks can vary in physical size with some disks getting as small as your thumb. The capacity of a commercial disk is currently up to about 4 terabytes allowing users to read and write to them. They are constructed from several key components:



Platter - Metallic disks where One or both sides of the platter are magnetized, allowing data to be stored. The platter spins thousands of times a second around the spindle. There may be several platters, with data stored across them

Head - The head reads magnetic data from the platter. For a drive with several platters there may two heads per platter allowing data to be read from top and bottom of each

Actuator Arm - used to move the read heads in and out of the disk, so that data can be read and written to particular locations and you can access data in a Random fashion, you don't need to read your way through the entire disk to fetch a particular bit of information, you can jump right there. Seek time is very low.



Power connector - provides electricity to spin the platters, move the read head and run the electronics **IDE connector** - allows for data transfer from and to the platters

Jumper block - used to get the disk working in specific ways such as RAID

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

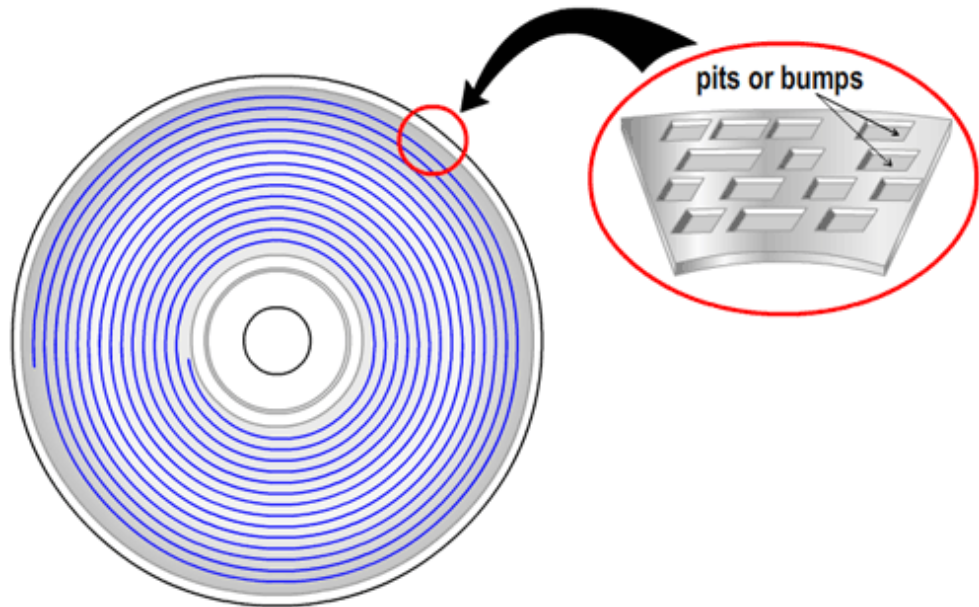
Writing data is very similar:

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

- Once the data sector that is required has spun around and under the write head, data is written to the platter

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.



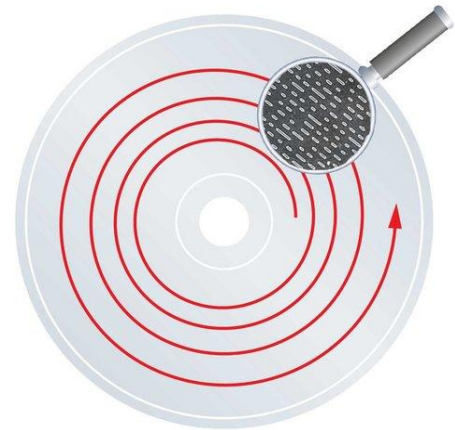
CD/ DVD disks:

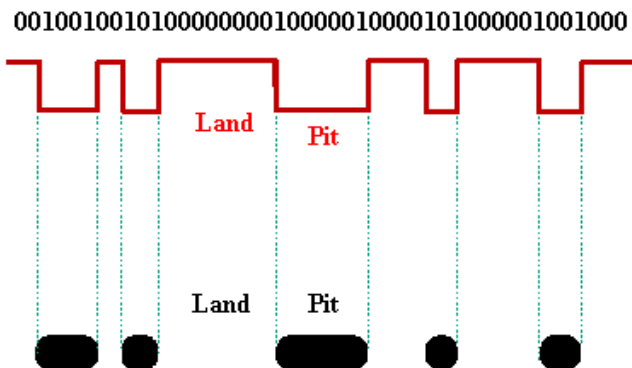
CDS and DVDS are described as OPTICAL STORAGE DEVICES.

Laser light is used to read data and to write data in the surface of the disk.

Both CDs and DVDs use a thin layer of metal alloy or light-sensitive organic dye to store the data. As can be seen in Figure, both systems use a single, spiral track which runs from the centre of the disk to the edge.

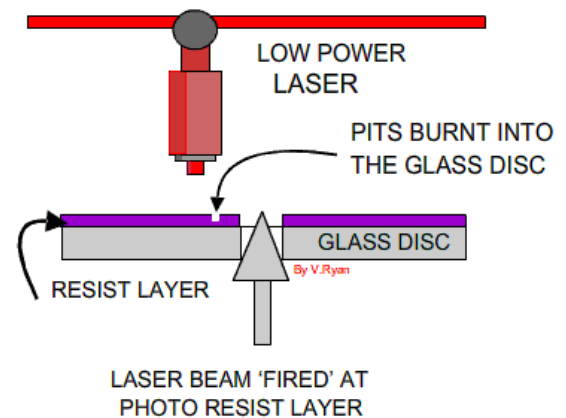
The data is stored in 'pits' and 'bumps' on the spiral track. A red laser is used to read and write the data. CDs and DVDs can be designated R (write once only) or RW (can be written to or read from many times).





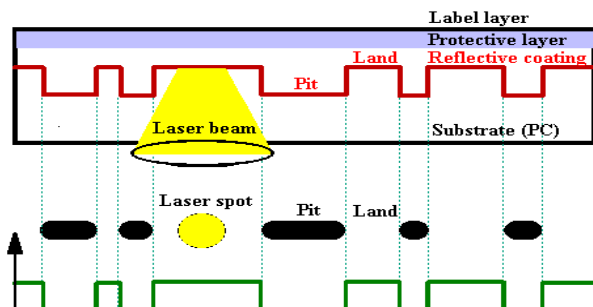
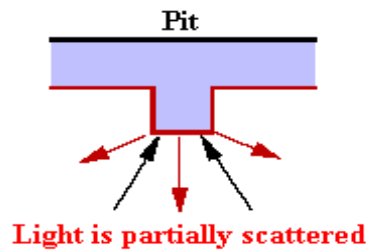
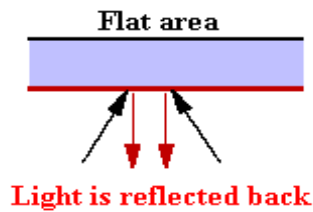
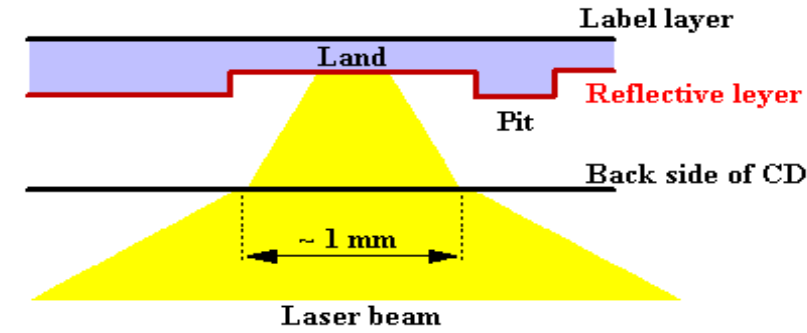
Writing to a CD/ DVD

1. A single track runs in a spiral pattern from the center 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 onto the CD-ROM, burning pits into the metal
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

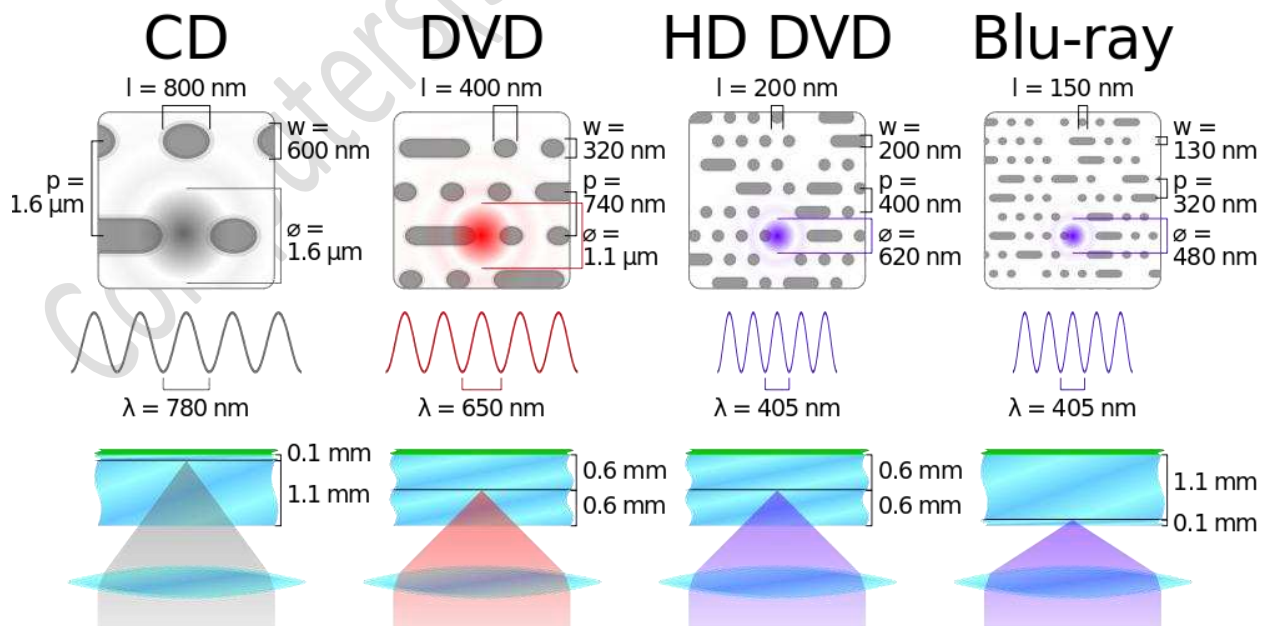


Reading from a CD/DVD

1. A single track runs in a spiral pattern from the center 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








Difference between CD, DVD, HD-DVD and Blu-Ray disks:



The main differences are:

Disk type	Laser colour	Wavelength of laser light	Disk construction	Track pitch (distance between tracks)
CD	red	780 nm	single 1.2 mm polycarbonate layer	1.60 μm
DVD	red	650 nm	two 0.6 mm polycarbonate layers	0.74 μm
Blu-ray	blue	405 nm	single 1.1 mm polycarbonate layer	0.30 μm

-  a blue laser, rather than a red laser, is used to carry out read and write operations; the wavelength of blue light is only 405 nanometres (compared to 650 nm for red light)
-  using blue laser light means that the 'pits' and 'bumps' can be much smaller; consequently, Blu-ray can store up to five times more data than normal DVD
-  Blu-ray uses a single 1.1 mm thick polycarbonate disk; normal DVDs use a sandwich of two 0.6 mm thick disks
-  using two sandwiched layers can cause BIREFRINGENCE (light is refracted into two separate beams causing reading errors); because Blu-ray uses only one layer, the disks don't suffer from birefringence
-  Blu-ray disks automatically come with a secure encryption system which helps to prevent piracy and copyright infringement.

Device	Type	Size	Image
<input type="checkbox"/> CD-ROM	<input type="checkbox"/> Read Only	650 - 900 MB	
<input type="checkbox"/> CD-R	<input type="checkbox"/> Write once then Read only		
<input type="checkbox"/> CD-RW	<input type="checkbox"/> re-Writable		
<input type="checkbox"/> DVD-ROM	<input type="checkbox"/> Read Only	4.7 - 9.4 GB	
<input type="checkbox"/> DVD-R	<input type="checkbox"/> Write once then Read only		

<input type="checkbox"/> DVD-RW	<input type="checkbox"/> re-Writable		
<input type="checkbox"/> DVD-RAM	<input type="checkbox"/> re-Writable		
<input type="checkbox"/> Blu-ray (BD) Disc	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	
<input type="checkbox"/> HD DVD (obsolete)			

Solid State Storage Media:

What is a Solid State Drive?

A Solid State Drive is a storage device which emulates a rotating hard disk drive but is made from semiconductor components.

Typically SSD are made using NAND flash memory, but a DRAM based device would also be considered a solid state drive. The 2.5" form factor is most popular, but flash cards and modules such as CompactFlash, SD Card, mSATA all the way up to PCIe boards are also SSD.



Since a SSD has no moving parts, it handles shock and vibration much better than a rotating disk drive. Without the spindle motor needed to rotate platters and an actuator to move the heads to the correct location, a SSD generally uses much less power than its mechanical HDD counterpart.



Smaller Physical Size – which could also be removable in the case of CompactFlash, SD Card, etc.



Lower Power Usage

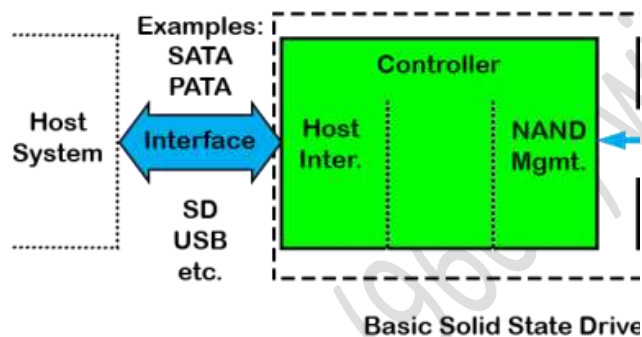


Higher Performance – especially small block transfers used for transactional processing



Lower Absolute Cost – if only a small amount of memory is needed

How do Solid State Drives Work?



A Solid State Drive emulates a hard disk drive in a host computer or embedded system. It does this with a specially designed controller which has the same electrical interface as a rotating hard disk drive. In many cases it has the exact same connector and physical form factor as the hard drive as well.

Other circuitry of the controller manages the NAND flash memory which stores the data of the SSD. While the controller function appears relatively straight forward, there are many behind the scenes issues with NAND flash management and it requires a great deal of planning to create a reliable SSD controller.

How long do Solid State Drives last?

The life of a SSD depends on the application which it is being used. Unlike rotating hard disk drives which SSD were designed to replace, the SSD memory has a finite number

of write/erase cycles. This makes the management of data written to the SSD extremely important.

As an example, a consumer 2.5" SATA SSD could last for decades in low intensity application, but may only last a few weeks in a high intensity data logging application.

Solid state storage devices are electronic and made as integrated circuits or chip. The currently predominant technology is flash memory, which like ROM holds data that are non-volatile but can be erased and rewritten in large blocks. We often refer to this as non-volatile memory.

Memory cards

Digital cameras use a slightly different form of solid-state memory, known as **XD (eXtreme Digital)** or **SD (Secure Digital)** cards. The technology is essentially the same as memory sticks.

These memory cards allow photos to be transferred from camera to computer via the USB port. Many printers and computers also have card slots allowing the device to read the memory card directly.

Each memory card is made up of NAND chips (see Section 6.4.2) and, as with all solid-state memories, there are no moving parts. All solid-state memories need to be treated with some care.

If they are removed from a device before being made safe (for example, while still in the middle of a read–write operation), data on the memory card or stick can be corrupted. In extreme cases, the memory card or stick become totally unusable. It is essential to wait for the message: 'it is now safe to remove your device' if plugged into a computer. With mobile phones or digital cameras, it is usually advisable to switch them off before removal of the card.

How flash memory works—the simple explanation

Flash works using an entirely different kind of transistor that stays switched on (or switched off) even when the power is turned off. A normal transistor has three connections (wires that control it) called the source, drain, and gate.



Think of a transistor as a pipe through which electricity can flow as though it's water.



One end of the pipe (where the water flows in) is called the source—think of that as a tap or faucet.



The other end of the pipe is called the drain—where the water drains out and flows away.



In between the source and drain, blocking the pipe, there's a gate. When the gate is closed, the pipe is shut off, no electricity can flow and the transistor is off. In this state, the transistor stores a zero.



When the gate is opened, electricity flows, the transistor is on, and it stores a one. But when the power is turned off, the transistor switches off too. When you switch the power back on, the transistor is still off, and since you can't know whether it was on or off before the power was removed, you can see why we say it "forgets" any information it stores.

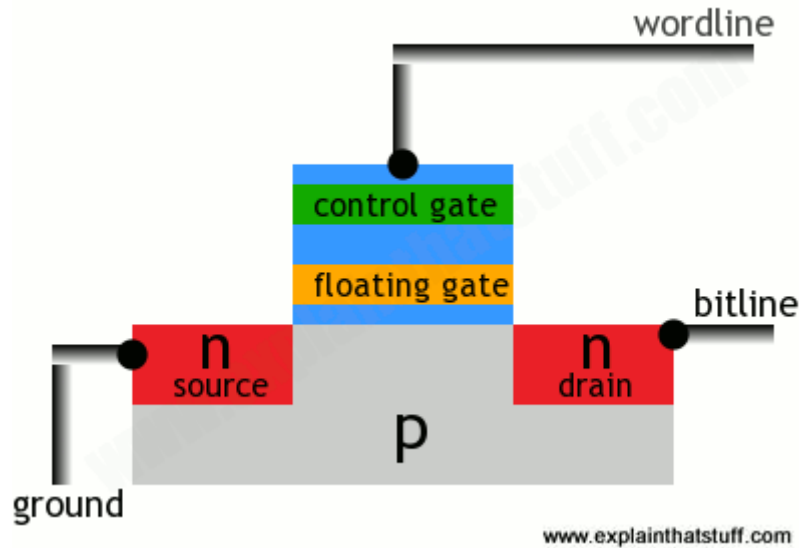
A flash transistor is different because it has a second gate above the first one. When the gate opens, some electricity leaks up the first gate and stays there, in between the first gate and the second one, recording a number one. Even if the power is turned off, the electricity is still there between the two gates. That's how the transistor stores its information whether the power is on or off. The information can be erased by making the "trapped electricity" drain back down again.

How flash memory works—a more detailed explanation

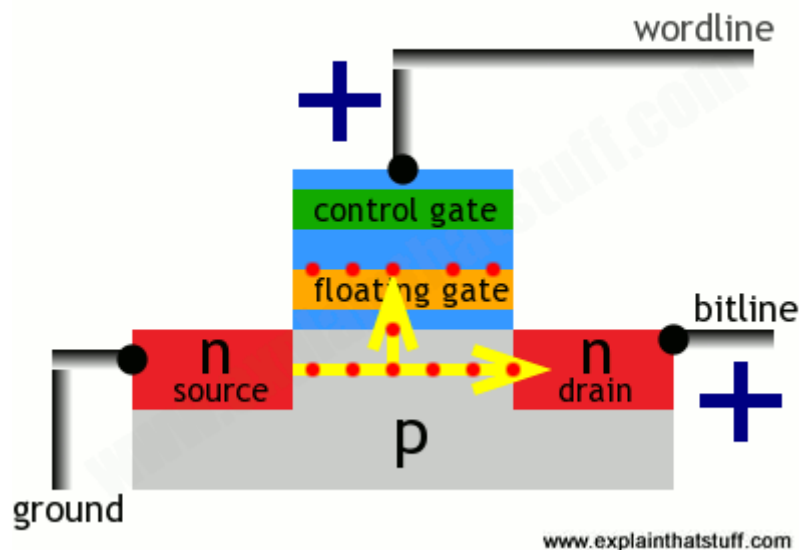
That's a very glossed over, highly simplified explanation of something that's extremely complex. If you want more detail, it helps if you read our article about [transistors](#) first, especially the bit at the bottom about MOSFETs—and then read on.

The transistors in flash memory are like MOSFETs only they have two gates on top instead of one. This is what a flash transistor looks like inside. You can see it's an n-p-n sandwich with two gates on top, one called a control gate and one called a floating gate. The two gates are separated by oxide layers through which current cannot normally pass:

Computer



In this state, the transistor is switched off—and effectively storing a zero. How do we switch it on? Both the source and the drain regions are rich in electrons (because they're made of n-type silicon), but electrons cannot flow from source to drain because of the electron deficient, p-type material between them. But if we apply a positive voltage to the transistor's two contacts, called the bitline and the wordline, electrons get pulled in a rush from source to drain. A few also manage to wriggle through the oxide layer by a process called tunneling and get stuck on the floating gate:



The presence of electrons on the floating gate is how a flash transistor stores a one. The electrons will stay there indefinitely, even when the positive voltages are removed and whether there is power supplied to the circuit or not. The electrons can be flushed

out by putting a negative voltage on the wordline—which repels the electrons back the way they came, clearing the floating gate and making the transistor store a zero again.

Not an easy process to understand, but that's how flash memory works its magic!

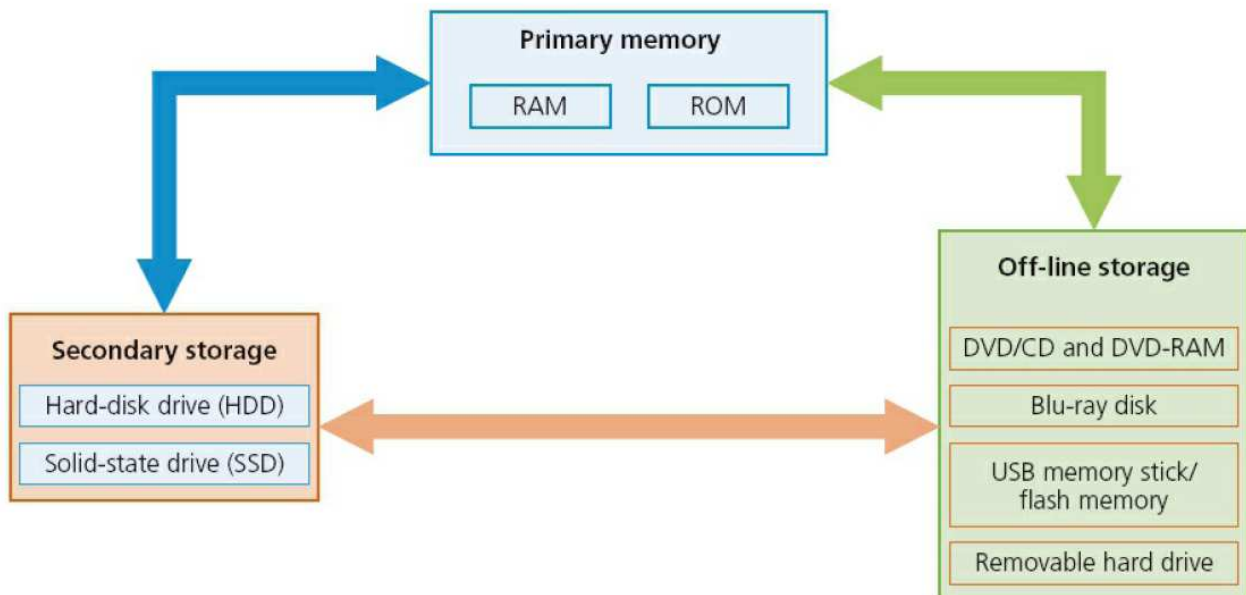
Data Storage:

In a computer, storage is the place where data is held in an electromagnetic or optical form for access by a computer processor. There are two general usages:

1) Storage is frequently used to mean the devices and data connected to the computer through input/output operations - that is, hard disk and tape systems and other forms of storage that don't include computer memory and other in-computer storage.

2) In a more formal usage, storage has been divided into:

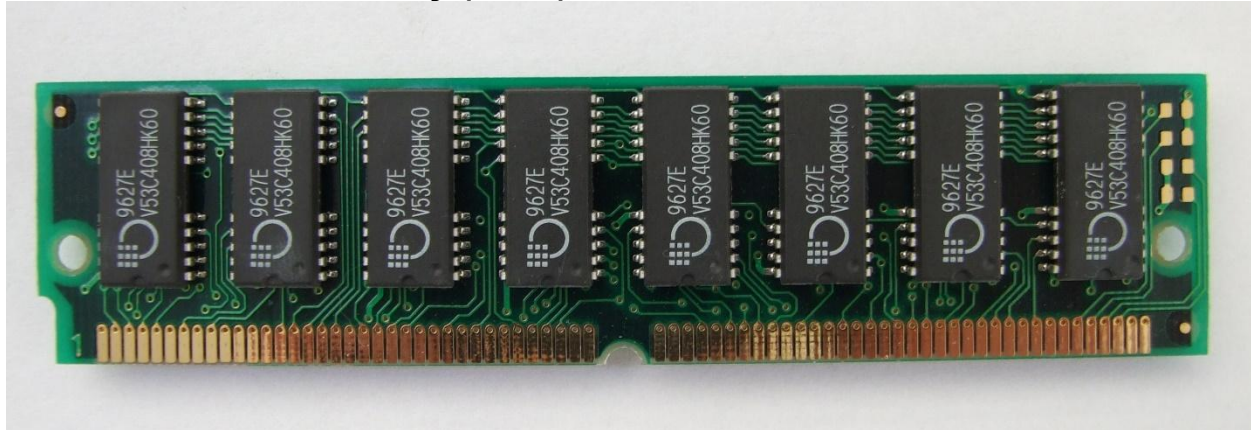
- a) **Primary storage:** Holds data in memory (sometimes called random access memory or **RAM, ROM**) and other "**built-in**" devices such as **the processor's L1, L2 cache**. Processor's **MEMORY CACHE** is the high speed portion of the memory; it is effective because most programs access the same data or instructions many times.
- b) **Secondary storage:** Holds data on hard disks, tapes, and other devices like USB, SD Cards, Zip and Floppy Disks and Optical disks etc.



Primary storage is much faster to access than secondary storage because of the proximity of the storage to the processor or because of the nature of the storage

devices. On the other hand, secondary storage can hold much more data than primary storage.

Primary memory Random Access Memory (RAM)



The features of RANDOM ACCESS MEMORY (RAM) are:

- 🟢 it is volatile/temporary memory (the contents of the memory are lost when the power to the RAM is turned off)
- 🟢 it is used to store:
 - data,
 - files,
 - or part of the operating system that are currently in use
- 🟢 it can be written to or read from and the contents of the memory can be changed.

In general, the larger the size of RAM the faster the computer will operate.

In reality, the RAM never runs out of memory; it continues to operate but just gets slower and slower. As the RAM becomes full, the processor has to continually access the hard disk drive to overwrite old data on RAM with new data.

By increasing the RAM size, the number of times this access operation is carried out is reduced, making the computer run faster. RAM is much faster to write to or read from than other types of memory; but its main drawback is its volatility.

Buffers are often use RAM since they need to be a fast memory and the data only needs to be held temporarily. As outlined earlier, buffers allow the processor to do other tasks while slower peripheral devices send data to and receive data from the computer.

There are currently two types of RAM technology:

- 🟢 Dynamic ram (DRAM)

Static RAM (SRAM).

Dynamic RAM (DRAM)



Each DYNAMIC RAM (DRAM) chip consists of a number of transistors and capacitors.

Each of these parts is tiny since a single RAM chip will contain millions of transistors and capacitors. The function of each part is:

Capacitor – this holds the bits of information (0 or 1).

Transistor – this acts like a switch; it allows the chip control circuitry to read the capacitor or change the capacitor's value.

This type of RAM needs to be constantly REFRESHED (that is, the capacitor needs to be recharged every 15 microseconds otherwise it would lose its value). If it wasn't refreshed, the capacitor's charge would leak away very quickly, leaving every capacitor with the value 0.

DRAMs have a number of advantages over SRAMs:

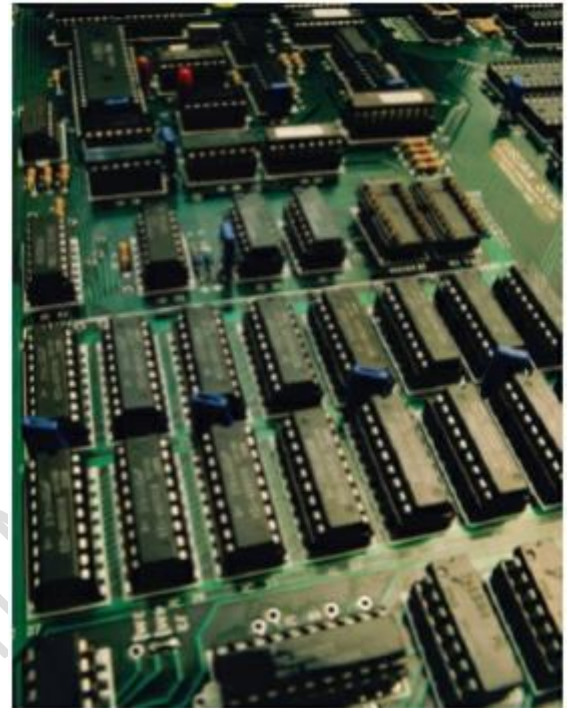
- They are much less expensive to manufacture than SRAM
- They consume less power than SRAM
- They have a higher storage capacity than SRAM.

Static RAM (SRAM)

A big difference between SRAM and DRAM is that this type of memory doesn't need to be constantly refreshed. It makes use of 'flip flops' which hold each bit of memory. SRAM is much faster than DRAM when it comes to data access (typically, access time for SRAM is 25 nanoseconds and for DRAM is 60 nanoseconds).

DRAM is the most common type of RAM used in computers, but where absolute speed is essential, then SRAM is the preferred technology.

For example, the processor's MEMORY CACHE is the high speed portion of the memory; it is effective because most programs access the same data or instructions many times. By keeping as much of this information as possible in SRAM, the computer avoids having to access the slower DRAM.



Read Only Memory (ROM)

The main features of READ ONLY MEMORY (ROM) can be summarised as follows:

- They are non-volatile/permanent memories (the contents of the memory remain even when the power to the ROM is turned off)
- They are often used to store the start-up instructions when the computer is first switched on (for example, ROM might store the basic input/output system (BIOS))
- The data or contents of a ROM chip can only be read; they cannot be changed.

Application

We will now consider an application, other than a computer, where both RAM and ROM chips are used. A remote-controlled toy car has a circuitry which contains both RAM and ROM chips. The remote control is a hand-held device. We will consider the function of each type of memory independently:

ROM

- stores the factory settings such as remote control frequencies
- stores the 'start-up' routines when the toy car is first switched on
- stores the set routines; for example, how the buttons on the hand-held device control turning left, acceleration, stopping, and so on.

RAM

- the user may wish to program in their own routines; these new instructions would be stored in the RAM chip
- the RAM chip will store the data/instructions received from the remote control

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