3. Magnetic Properties of Materials

Part – A

MAGNETIC MATERIALS

1. **What is Bohr magnetron?**
When the atom is placed in a magnetic field, the orbital magnetic moment of the electron is quantized. A quantum of magnetic moment of an atomic system is known as Bohr magnetron.

$$\mu_B = \frac{eh}{4\pi m}$$

2. **What is Curie constant & Curie law?**

Paramagnetic susceptibility $\chi = \frac{N\mu_0\mu_m^2}{3kT}$ (or) $\chi = \frac{C}{T}$ where N is the number of atoms per unit volume; μ_0 is the permeability of free space; μ_m – Induced dipole moment

Thus "*susceptibility of a paramagnetic substance varies inversely with the tempecture*" is called Curie law and *C* is the curie constant.

3. **What is Curie – Weiss law?**
Ferromagnetic materials exhibit spontaneous magnetization below a tempecture called the curie tempecture and above it becomes paramagnetic and obeys Curie Weiss law given by
Susceptibility $\chi = \frac{C}{T-\theta}$. Where *C* – Curie constant & θ – paramagnetic curie tempecture.

4. **What is domain theory of ferromagnetism?**
According to Weiss, *a ferromagnetic specimen consists of large number of small regions called domains which are spontaneously magnetized due to the parallel alignment of all magnetic diploes. The direction of spontaneous magnetization varies from domain to domain.*

5. **What are energies involved in origin of domains in ferromagnetic material?**
Magnetostatic energy, Crystalline (or) anisotropic energy, Domain wall energy, Magnetostriction energy.

6. **On the basis of magnetic moments how the materials are classified as Dia, Para, Ferro, Antiferro & ferri magnetic?**
(i) Materials which does posses any permanent dipole moment are known as diamagnetic materials
(ii) If the permanent dipole do not interact among themselves and are align in random direction, then those materials are paramagnetic.
(iii) If the permanent dipole are strong and align themselves in parallel, then those materials are called diamagnetic.
(iv) If the permanent dipole are strong and align themselves antiparallel with equal magnitude, then those materials are called Antiferromagnetic
(v) If the permanent dipole are strong and align themselves antiparallel with unequal magnitude, then those materials are called Ferrimagneic

7. **Give the properties of Diamagnetic materials?**
   (i) Permanent dipoles are absent. Therefore the magnetic effects are very small
   (ii) When placed inside the magnetic field, magnetic lines of forces are repelled
   (iii) The magnetic material have negative susceptibility
   (iv) Magnetic susceptibility is independent of applied field strength and tempecture
   (v) Relative permeability is slightly less than unity
   (vi) Example: Gold, Bismuth and Organic materials
8. **Give the properties of Paramagnetic Materials?**
   (i) It posses permanent magnetic dipoles
   (ii) When placed inside the magnetic field, it attracts the magnetic lines are forces
   (iii) In the absence of the magnetic field, the dipoles are randomly oriented. There is a small amount of magnetic moment in the absence of external field.
   (iv) When magnetic field is applied, magnetic moment along the field direction increases with increasing magnetic induction.
   (v) Paramagnetic susceptibility is positive and greatly depends on tempecture.
   (vi) Paramagnetic susceptibility is independent of applied field strength.
   (vii) When the tempecture is less than Curie tempecture it becomes diamagnetic.
9. **What are the properties of Ferro magnetic materials?**
   (i) It exhibits magnetization even in the absence of external field
   (ii) This materials exists as ferro magnetic when tempecture is below ferromagnetic curie tempecture and become paramagnetic above ferromagnetic curie tempecture
   (iii) It consists of number of small spontaneously magnetized region called domains
   (iv) During heating they loss their magnetization slowly
   (v) Spin alignment are parallel in same direction
   (vi) They attracts magnetic lines of forces strongly
   (vii) Susceptibility is very large & positive
10. **What are the properties of ferri magnetic materials?**
   (i) It posses net magnetic moment
   (ii) Magnetic susceptibility is very large & positive. It is given by $\chi = \frac{C}{T \pm \theta_N}$
   Where θ_N- Neel Tempecture.
   (iii) Spin alignment is antiparallel of different magnitude
   (iv) The susceptibility is graphically tempecture dependent.
11. **What are the essential differences between hard and soft magnetic materials?**

S.No	Hard magnetic materials	Soft Magnetic Materials
1.	They have large hysteresis loss	They have small hysteresis loss
2.	The eddy current loss is high	Eddy current loss is low
3.	They have small values of permeability & Susceptibility	They have large values of permeability & Susceptibility
4.	Domain wall movement is difficult& irreversible in nature	Domain wall moves easily& reversibly
5.	The coercivity & retentivity are large	The coercivity & retentivity are small

6.	Eg: Carbon steel, Tungsten Steel, Chromium Steel.	Eg: Iron, Ferrites, Silicon Alloys

12. Define Susceptibility?

The ratio of the intensity of magnetization produced in the sample (I) to the magnetic field intensity which produces the magnetization (H). i.e., $\chi = \frac{I}{H}$

13. What is antiferromagnetism?

Electron spin of neighbouring atoms are align antiparallel, their susceptibility is small and positive, and they greatly depends on tempecture.

14. What are Ferrites and mention its types?

Ferrites are modified structure of iron with no carbon atoms in which the adjacent magnetic moment are of unequal magnitudes aligned in antiparallel direction.

General Formula: $X^{2+}\ Fe^{3+}O_4^{2-}$

Types: Regular Spinal, Inverse Spinal

15. **State the applications of ferrites?**

(i) They are used in transformer cores for high frequencies up to microwaves.

(ii) They are used in radio receivers to increase the sensitivity and selectivity of the receiver

(iii) They are used in digital computers and data processing circuits

(iv) They are used in power limiting and harmonic generation devices

16. What is ferrite core memory?

It is the memory made up of a ferrite core in the form of rings used for random storage of data ‘0’ & ‘1’ by magnetizing the ring in any of the two opposite direction.

17. **What do you understand from bubble storage?**

It is the direct access storage medium made up of a soft magnetic materials with magnetic domains of few ‘µm’ in diameter. These magnetic bubbles are the electronic analogue of the magnetic disc memories used in computers.

18. **Define Hysteresis?**

When the ferromagnetic material undergo a cycle of magnetization, the intensity of magnetization (I) & magnetic flux density (B) lags behind the applied magnetic field strength (H) & this process is called Hysteresis.

19. What is the principle of magnetic recording system?

It states the data in the form of magnetization pattern as a sequence of binary magnetization states in the magnetic medium because the ferromagnetic material produces the magnetic dipoles align themselves parallel to each other.

20. What are the advantages and disadvantages of magnetic discs?

Advantage:

(i) It has very large storage capacity

(ii) Thousands of files can be permanently stored

(iii) Very high speed in writing & reading the information

(iv) Prevented from dust particles, because it is sealed

Disadvantage:

(i) It is very costly

(ii) If data is once corrupted, there is a heavy loss of data

<u>Part – B</u>

1. How the hysteresis curve is explained on the basis of the domain theory?

When a Ferromagnetic is subjected to external field, there is an increase in the value of the resultant magnetic moment due to

(i) The movement of domain walls

(ii) The rotation of domains

When a weak external field is applied, the domain walls are displaced slightly in the soft direction of magnetization. This gives rise to small magnetization corresponding to the initial portion of the hysteresis curve (OA) as shown in figure .Now, if applied field is removed, then the domains return to its original state and it is known as "**Reversible Domains**".

When a strong external field is applied, large number of domains contributes to the magnetization and thus the magnetization increases rapidly with "H"↑

Here, even when the field is removed, because of the displacement of domain wall to a very large distance. The domain boundaries do not come back to their original position. This process is indicated as (AB) in Figure and this domains are called **"Irreversible Domains".**

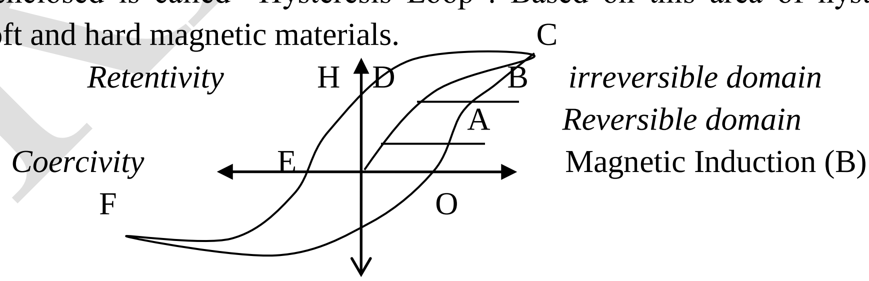
At point "B" all the domains have got magnetized along the soft direction. Now, when the field is further increased, the domains start rotating along with the field direction and the anisotropic energy is stored in the "*Hard Direction*" represented as "BC" in figure

Thus the specimen is said to attain the maximum magnetization. At this position, even after the removal of external field the material possess maximum magnetization called **"Retentivity"** represented by "OD" in figure

Actually after the removal of the external field, the specimen will try to attain the original configuration by the movement of Bloch wall. But this movement is stopped due to the presence of impurities, lattice imperfections, etc., therefore to overcome this, a large amount of reverse magnetic field is applied to the specimen. The amount of energy spend to reduce the magnetization of Zero is called **"Coercivity"** represented by "OE" in figure

<u>Hysteresis Loss:</u>

It is the loss of energy in taking a ferromagnetic specimen through a complete cycle of magnetization and the area enclosed is called "Hysteresis Loop". Based on this area of hysteresis, the magnetic are classified as soft and hard magnetic materials.



2. Describe the structure of ferrites? How the magnetic moment of ferrite molecule is calculated?

Substance which possess a spontaneous magnetization in which the magnetic moments of the two sub lattice are opposite in direction but not exactly equal in magnitude are called "Ferrites".

Ferrites are compounds of iron oxides with oxides of other metals

General Formula: $X^{2+}\ Fe_2^{3+}\ O_4^{2-}$

Where $X^{2+} \rightarrow Mg^{2+}, Zn^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+}$, etc.,

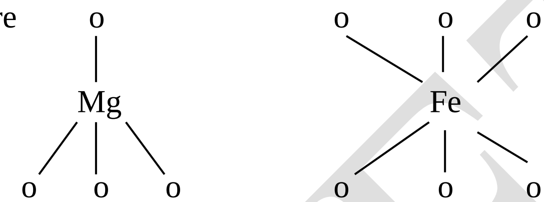
Examples: If X^{2+} is Ni^{2+} then $Ni^{2+}\ Fe_2^{3+}\ O_4^{2-}$ is a nickel ferrite.

X^{2+} is Fe^{2+} then $Fe^{2+}\ Fe_2^{3+}\ O_4^{2-}$ is a ferrous ferrite.

Ferrites formed usually have a face centered cubic structure of oxygen ions closely packed together with the divalent and trivalent metal ions in the interstitial sites. This structure is called spinal structure. There are two types of ferrites.

(i) Regular spinal ferrite structure

(ii) Inverse spinal ferrite structure



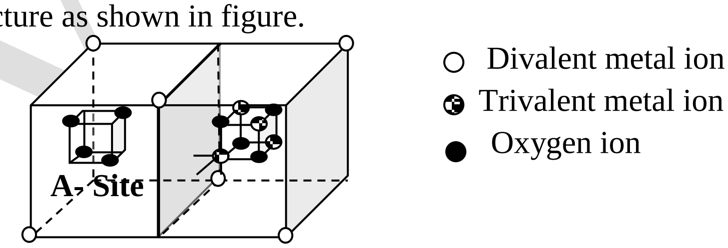
(i) Regular spinal ferrite structure:

In this type each divalent metal ion is surrounded by four O^{2-} Ions in the tetrahedral fashion. It is called "A" site. Totally in a unit cell, there will be 8 tetrahedral sites (8A)

Each trivalent metal ion is surrounded by six O^{2-} Ions in the octahedral fashion. It is called "B" site. Totally in a unit cell, there will be 16 octahedral sites (16B)

Example: $Mg^{2+}\ Fe^{3+}\ O_4^{2-}$

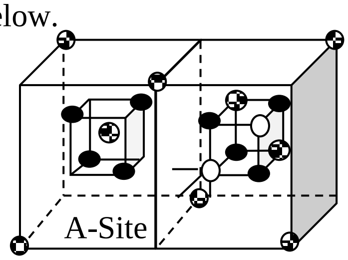
Thus in the regular spinal, each divalent metal ion (Mg^{2+}) exists in a tetrahedral form (A site) and each trivalent metal ion (Fe^{3+}) exists in an octahedral from (B site). Hence the sites "A" and "B" combine together to form a regular spinal ferrite structure as shown in figure.



(ii) Inverse spinal ferrite structure

Example: $Fe^{3+}\ [Fe^{2+}\ Fe^{3+}]\ O_4^{2-}$

In this, the trivalent metal ions (Fe^{3+}) occupies all the A sites (tetrahedral) and half of the B sites (octahedral) also. Thus the left out B sites will be occupied by the divalent (Fe^{2+}) metal ions. The inverse spinal ferrite structure is shown in figure below.



<u>Types of interaction present in ferrites:</u>

According to Neel, there are three types of interaction, AA, BB and AB. Out of which AA and BB are negative and considerably weak than AB interaction. Thus the effect of AB interaction dominates and gives rise to antiparallel spin arrangement.

<u>Magnetic Moment of a ferrite molecule:</u>

The orbital and spin magnetic moment of an electron in an atom can be expressed in terms of Bohr magnetron $\mu_B = \left(\frac{eh}{4\pi m}\right)$, saturation magnetization of a ferrite molecule can be calculated from number of unpaired spins of Fe^{2+} and Fe^{3+}

Consider Fe^{3+} [Fe^{2+} $Fe^{3+]}$ O_4^{2-}

(i) Fe^{2+} ions have 6 electrons in 3d shell. Out of '6', 2 electrons are paired and 4 electrons are unpaired. Therefore, Fe^{2+} gives 4 Bohr Magnetron.

↑↑↑↑↑
↓↓↓↓↓ ↑↑↑↑

(ii) Fe^{3+} ions have 5 electrons are unpaired

Therefore, $Fe3^{+}$ gives 5 Bohr Magnetron

Since we have two Fe^{3+}, totally the Fe^{3+} gives 2x5=10 Bohr magnetron.

Total magnetization = 4+10=14 Bohr Magnetron. But total magnetic moment got only 4.08 MB. Because, in ferrites half of the magnetic spins of Fe_2^{3+} ions are parallel in one direction and the remaining half of Fe_2^{3+} ions are parallel in opposite direction and hence they cancel each other and exists 4 Bohr magnetron which is nearly equal to 4.08 MB.

3. Classify the magnetic materials on the basis of their spin? (or) Explain the origin of magnetic moments?

The magnetic moment originates from the orbit motion and spinning motion of electrons in an atom. In general, there are three contributions to the angular momentum of an atom.

(i) Orbital angular momentum of the electrons:- $\mu_\circ$

Consider an electron revolving in an orbit with radius 'r' moving with linear velocity 'v' and produces a constant angular velocity 'w'. Any electron revolving around orbit produces magnetic field perpendicular to its plane which produces an orbital magnetic moment given by

$$\mu_0 = IA$$

$$= \left(\frac{ew}{2\pi}\right)\pi r^2$$

But v = rω and $\omega = \frac{v}{r}$

$$\therefore \mu_0 = \left(\frac{evr}{2}\right)$$

$$= -e\left(\frac{mvr}{2m}\right) \qquad \mu_\circ = \left(\frac{-el}{2m}\right)$$

By quantum theory, this orbital magnetic moment of an atom can be expressed in Bohr magnetron given by μ_B = 9.27 x 10^{-24} Am^2

(ii) Electron spin magnetic moment (μ_S)

In an atom, every two electrons will form a pair with opposite spins. Thus the resultant spin magnetic moment is zero. But in magnetic materials, the unpaired electrons spin magnetic moments interacts with the adjacent atom's to form unpaired electron spin magnetic moment which is responsible for ferro and paramagnetic behaviour of materials. Accordingly to Quantum theory, spin magnetic moment $\mu_S = \frac{e}{2m} S$

Where μ_S = ±1 Bohr Magnetron.

(iii) <u>Nuclear spin magnetic moment</u> (μ_N)

The mass of the nucleus is larger than that of electron by a factor of the order of 10^3. Hence, nuclear spin magnetic moment is of the order of 10^{-3} Bohr magnetron.

Since μ_S and μ_N are very small, then the practical purpose, the total magnetic moment arises due to spin magnetic moment.

4. (a) Explain the formation of domain structure in a Ferro magnetic material?

(b) Write a short note on (i) Exchange energy (ii) Anisotropy energy (iii) Bloch wall energy and (iv)Magnetostrictive energy? (or) what are the energies involved in domain growth? (or) explain the origin of Domain theory of ferromagnetism?

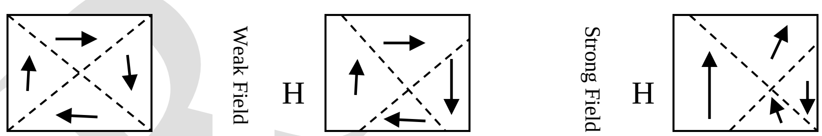
According to Weiss, *Ferro magnetic materials consists of large number of small regions called domain. Each domain varies from $10^{-6}$to entire size of the crystal.* In each domain the spontaneous magnetization is due to parallel alignment of all magnetic domains. The direction of spontaneous magnetization varies from domain to domain. Hence the resultant magnetization may be zero or nearly zero, when the external field is applied. There are two ways of alignment of a random domain:

(i) By the motion of domain walls:-

The volume of the domains that are favorably oriented with respect to the magnetizing field increases at the cost of those that are unfavorably oriented as shown in figure

(ii) By the rotation of domains:-

When the applied magnetic field is strong, rotation of the direction of magnetization occurs in the direction of the field as shown in figure



H = 0

By bitter powder pattern, when a drop of colloidal suspension of finely divided ferromagnetic material has strong magnetic field near boundaries when external magnetic field is applied domain walls are move. The domain walls & their movements can be observed from microscope.

In the process of domain growth, four types of energies are involved:

(i) <u>Exchange energy (or) Magnetic field energy (or) Magneto-static energy:-</u>

"The interaction energy makes the adjacent dipoles align themselves. It arises from the interaction of electron spins".

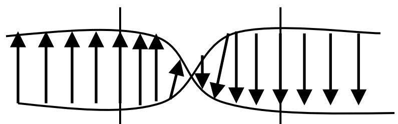
This exchange energy is the energy required in assembling the atomic magnets in single domain and this work done is stored as potential energy, the size of domain may be obtained from the principal of minimum energy volume of domain = 15^2 to 10^{-6} cm^3.

(ii) <u>Anisotropy energy</u>:-

In ferromagnetic crystals, energy of magnetization is found to be a function of crystals orientation i.e., crystal have easy and hard direction of magnetization.
Example: In BCC iron, easy direction is [100], the medium direction is [110] and the hard direction is [111].
"The excess energy required to magnetize a specimen in a particular direction over that required to magnetize it along the easy direction" is called crystalline anisotropy energy.

(iii) Domain wall energy (or) Bloch wall energy:-

The thin region that separates adjacent domains magnetized in different direction is called "Domain wall energy". Bloch walls are 200 to 300 lattice constant thicknesses. It changes the spin when transfer from one domain to other. The exchange energy is lower when the change is gradual but the anisotropy energy is less when spin change abruptly. Hence the Bloch wall compromise between two.

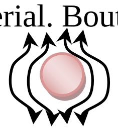
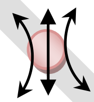


(iv) Magnetostrictive energy:-

When the domains are magnetized in different directions, they will either expand (or) shrink. Therefore there exists a deformation (i.e., change in dimension of a material) when it is magnetized this phenomenon is known as Magnetostriction and the energy produced is Magnetostrictive energy.

5. Distinguish briefly about diamagnetic material, paramagnetic material and ferromagnetic material?

S.No		**Diamagnetic material**	**Paramagnetic material**	**Ferromagnetic material**
1.	Definition	The material with no permanent dipole moment. The external field decreases the magnetic induction present in the specimen	The material with permanent dipole moment but do not interact among themselves. The external magnetic field increases the magnetic induction present in the specimen	The material with strong permanent dipole moment and interact among themselves. The external field increases a large magnetic induction in the specimen.
2.	Susceptibility and its temperature dependence	It is negative and independent of temperature and applied magnetic field.	It is always positive and small and it is inversely proportional to absolute temperature of material	It is always positive and large and depends on temperature in complex manners.

3.	Behaviour of material in magnetic field	The magnetic lines of forces are repelled away from the material. Bout > Bin 	The magnetic lines of forces are attracted towards the centre of material. Bin > Bout 	The magnetic lines of forces are highly attracted towards the centre of material. Bin >> Bout 
4.	Spin on magnetic moment alignment	No spin (or) magnetic moment	All spins (or) magnetic moments are randomly oriented	All spins (or) magnetic moments are orderly oriented.
5	Origin	Arises from lamer precession	Arises from the magnetic moments orientation	Arises from spontaneous magnetization due to total molecular magnetic field.
6.	Magnetic phase transition	At low temperature, super conductor are diamagnetic when temperature increases it becomes conductor.	When temperature is less than curie temperature. It is diamagnetic. But paramagnetic curie temperature is low.	When temperature is higher than curie temperature it is paramagnetic. But in ferromagnetic curie temperature is high.
7.	Examples	Hydrogen, Bismuth	Aluminum, Platinum	Iron, Nickel and Cobalt.

6. What are hard magnetic materials and soft magnetic material? Give its properties?

Hard magnetic materials:-

The materials which are very difficult to magnetize and demagnetize called hard magnetic materials.

Soft magnetic materials:-

The materials which can be easily magnetized and demagnetized are called soft magnetic materials.

S.No	Soft Magnetic Materials	Hard Magnetic Materials
1.	They can be easily magnetized and demagnetized.	They cannot be easily magnetized or demagnetized.
2.	The hysteresis loop is narrow	The hysteresis loop is broad

3.	The hysteresis loss is minimum	The hysteresis loss is maximum
4.	Susceptibility and permeability are high	Susceptibility and permeability are low
5.	Retentivity and coercivity are small	Retentivity and coercivity are large
6.	They have low eddy current loss	They have high eddy current loss
7.	These materials are free from irregularities like strain and impurities.	These materials have large amount of impurities and lattice defects
8.	It is used to make temporary magnets	It is used to produce permanent magnets
9.	Eg: Iron, Silicon, Alloys, Ferrites	Eg: Carbon steel Tungsten steel, chromium steel.

7. In detail Explain how data are stored in magnetic materials? What are functions of reading & writing Heads? How they are designed?

Magnetic recording involves the storage of data in the form of magnetization pattern as a sequence of binary magnetization states in the magnetic medium.

Reading Process:

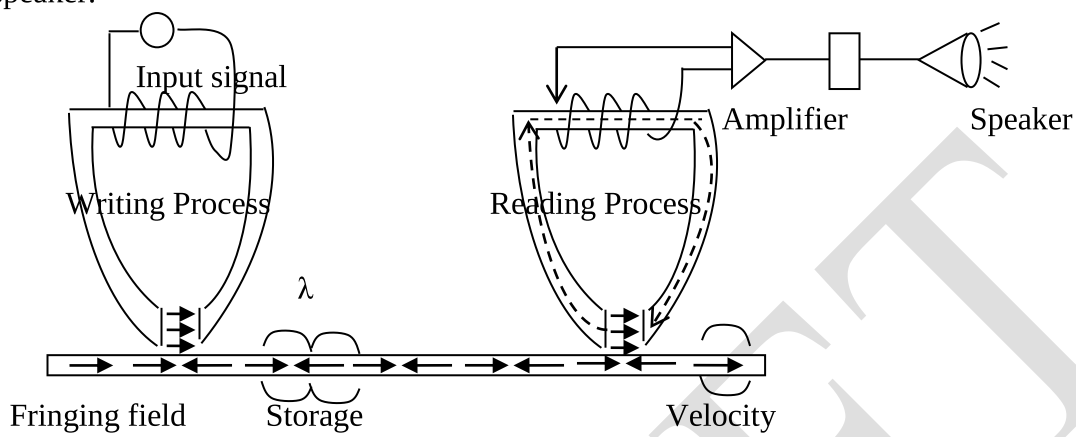
An audio tape is simply a polymer packing tape coating with magnetic oxide. The audio signal to be recorded is converted in to current signal & it is passed through electromagnet made up of ferrite which has small air gap of about 0.3m wide. Whenever the current signal passes through the electromagnet, it produces a magnetic field in the material which produces a magnetic field in the recording head (air gap)

When the tape touches the head, the magnetic field present in the head magnetize the magnetic material present in the tape. The recording on the tape is done by fringing magnetic field around the air gap region. This fringing magnetic field magnetizes the audio tape passing under the head at constant speed. Th intensity of the fringing magnetic field varies with the intensity of the current signal. Thus the electrical signal is stored by means of spatial magnetic pattern on the tape. This type of magnetic recording is called *longitudinal recording*

Writing Process:-

The reading process is based on the principle of Faraday’s law of electromagnetic induction. A portion of magnetic field present in the tape penetrates through the recording head.

This magnetic field loops around the core of the head. As the tape is moving with a constant velocity, the magnetic field present in the tape while flowing through the core gets converted in to the corresponding voltage signal & the voltage signal is converted into an audio signal by a amplifier & loud speaker.



8. Explain in detail on different magnetic storage data. What are their relative merits & demerits?

In general memory units are the devices used to store the information in the form of bits. [8 bit =1 byte] The memory units are classified as

(i) Main memory (or) Internal memory

(ii) Auxiliary memory (or) External memory

Main Memory:

The memory unit of CPU is called main memory. Thus data's are write and finally be erased if necessary. Eg: EPROM, ROM, RAM etc.,

Auxiliary Memory:

This type of memory is also referred to as back-up storages because; it is used to store large volume of data on permanent basis. This date can be accessed or recopied if necessary.

Eg: Magnetic tapes, Magnetic disk, Ferrite core memories and Bubble memories.

1. Magnetic Tape:

The tape is a plastic ribbon with metal oxide material coated on one side which can be magnetized, in this information can be written and also can be read by write/read heads.

Information recorded in the tape is in the form of tiny magnetized and non-magnetized spots on the metal oxide coating. The magnetized spot represents '1' sun magnetized spot represent '0' in binary code. The information can be accessed, processed, erased and can be stored again in same area.

Advantages:-

(i) Storage capacity is large

(ii) Easy to handle

(iii) Loss expensive

(iv) Erased and reused.

Disadvantages:-

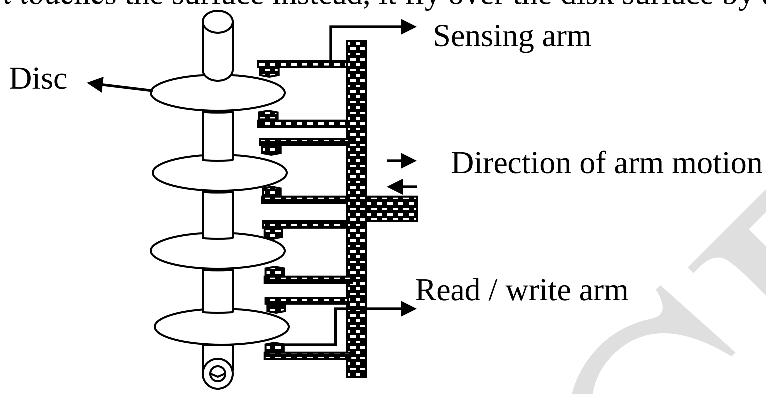
(i) It consumes lot of time.

2. **Magnetic Disc Devices:**

(A) Hard disk drives:

It is the direct access storage device made up of hard aluminum platters. This platter surface is carefully machined for flat. This surface is coated with magnetic oxides and built in to a bar.

Similar such disks are mounted on a vertical shaft, forming a disk pack as shown in figure. The drive mechanism drives the disc pack with the spindle. The data is written can read by the R/W heads in the horizontal sensing arms by moving in and out between the platters with the precaution that the R/W head doesn't touches the surface instead, it fly over the disk surface by a fraction of a mm.



Advantages:-

(i) It has large storage capacity.
(ii) Thousand of files can be permanently stored.
(iii) Very high speed in reading and writing the information
(iv) This is prevented from dust, since they are sealed.

Disadvantages:-

(i) It is very costly
(ii) If data is completed, there is a heavy loss.

(B) Floppy disc drives:

Floppy is made of a very thin and flexible plastic materials coated with magnetic materials. This disc is inserted in floppy disc drive for read/write operation by the read/write head in the disc. Size: 5.25" called mini floppy, 3.25" called micro floppy.

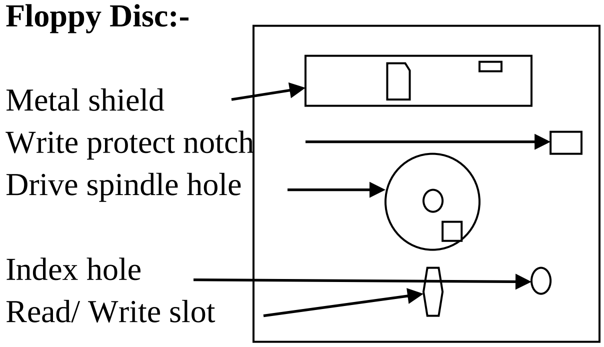
Organization:-

Surface of the floppy disc is divided into a number of concentric circles known as tracks where the information is recorded. The tiny magnetic spots are used to record the logic 1 (or) 0 state. The spot magnetized in one direction are '1' state and in other direction are called '0' state. Each track has number of sectors

Operation;-

When the floppy is put in drive unit. When drive is operated. The floppy disc is rotated which makes physical contact with read/write head. This magnetic material movement is controlled by serve mechanism.

Floppy Disc:-



<u>Advantages:-</u>

(i) Storing and transporting of data is easier.
(ii) Cost is less
(iii) It can reused many times

<u>Disadvantages:-</u>

(i) Storage capacity is less
(ii) Care to be taken for handling.

3. <u>Ferrite Core Memory:</u>

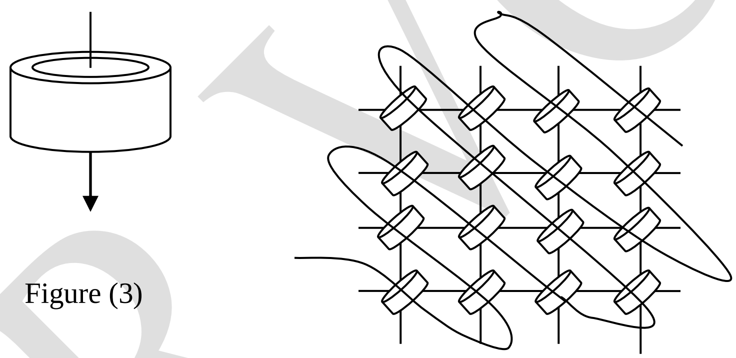


Figure (3)

Here the magnetic core consists of a ferrite core in the shape of a torrid ring as shown in figure.

We know that the ferrites have square hysteresis loop and low coercivity as shown in figure. Such hysteresis is used for making core memory as a different form of magnetic recording.

The magnetic cones of the memory are arranged in a matrix interlaced thought fine metal wires both horizontally and vertically as shown in figure (3)

A change in the state only occurs during reinforced magnetization i.e. both the horizontal current and vertical current pass through the core in same direction. The current passing through one of the wires will not induce a change in the magnetization of the cores reading of the magnetic cores is achieved using a third sense wire threaded through the core. It will pick up an induced voltage, if the core changes state. To facilitate a fast response for a high speed memory, soft magnets are always used in the core.

4. <u>Magnetic Bubbles Memories:</u>

Magnetic bubbles are soft magnetic materials with magnetic domains of a few micrometers in diameter.

<u>Construction:-</u>

Bubble memory consists of magnetic garnets deposited on a non-magnetic substrate made up of Gadolinium Gallium Garnet (GGG)

When a magnetic field is applied by placing in between two permanent magnets, the magnetic domains contracts and finally forms a small cylindrical domain area which is called magnetic bubble.

These bubbles constitute a magnetic region of one polarity surrounded by magnetic region of opposite polarity.

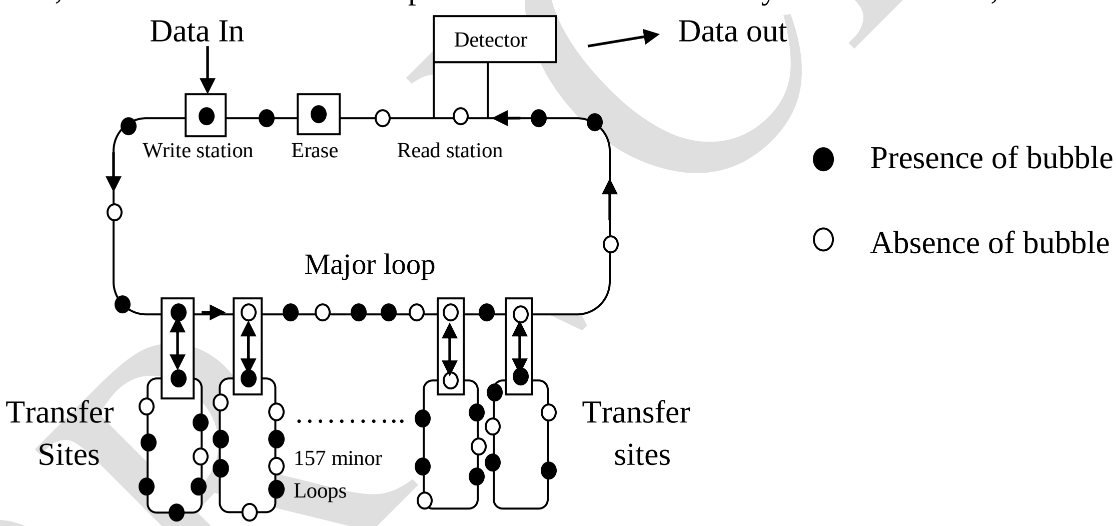
The information is represented as the presence (or) absence of a bubble at specified location. The bubble position remains unchanged even in the absence of electric power. These bubbles can be moved electronically through the access lines at very high speed and hence its access and storage time is less. Here presence of bubble is logic ‘1’ state and absence is logic ‘0’ state. The schematic diagram show in fig. It consists of ‘1’ major loop and ‘15’ minor loops which are arranged from right to left. Each minor loops has 641 bubble sites, thousands of coded characters may be stored in a single chip.

Writing Operation:-

When a data has to be stored, the bubbles from the minor loops are transferred to major loop and it goes to write station. In write station the message is entered and the bubble site again comes to minor loop.

Reading Operation:-

To read the data from the storage, the bubble from minor loops are transferred to major loops and it goes to read station, then it comes to minor loop. The data can be altered by the erase station, if we need to erase it.



Advantages:-

(i) Large amount of data stored permanently

(ii) Data is not lost while power is off

(iii) It is a non-volatile memory

(iv) Bubble sites are moved electronically

Disadvantages:-

(i) It requires a high recording time for storing and retrieving the data.