Course Name:- Basic Science (PHYSICS)

Unit No:2

Unit Name: Magnetic field, magnetic field intensity, and its unit, magnetic lines of force and magnetic flux.

Unit Outcomes (UO2b): Describe the concept of given magnetic intensity and flux with relevant units.

Learning Outcomes (LOs):

LO3: Student will be able to explain magnetic field and magnetic field intensity and its units, magnetic lines of force and magnetic flux.

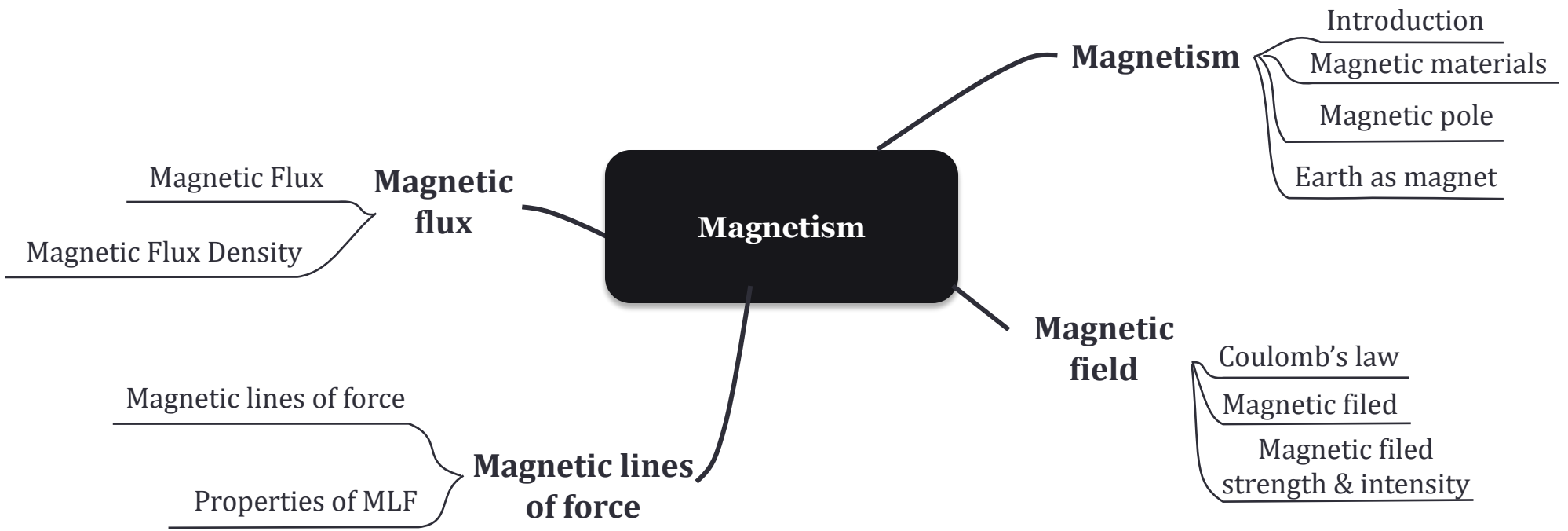
CONTENT

- Magnetic field
- Magnetic field intensity
- Magnetic lines of force
- Magnetic flux

LEARNING OBJECTIVES

- Student will be able to explain magnetic field and magnetic field intensity and its units, magnetic lines of force and magnetic flux.

Concept Map


Magnetism
Magnetism
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Magnetic pole
Earth as magnet
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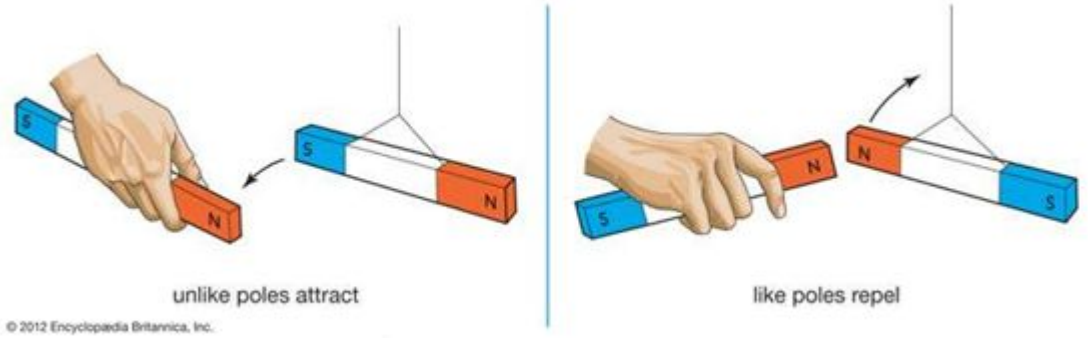
Magnetic filed strength & intensity
Magnetic lines of force
Magnetic lines of force
Properties of MLF

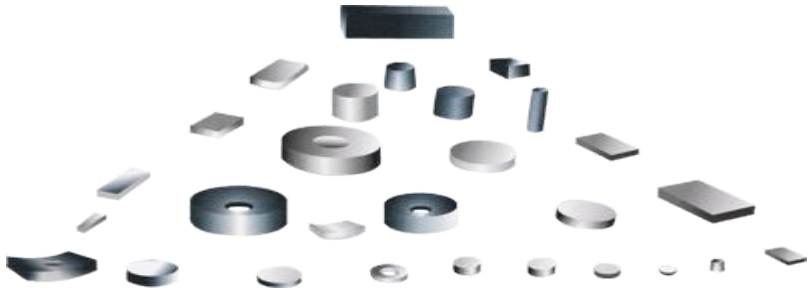
INTRODUCTION: magnets & MAGNETISM

- Magnets can be found in a natural state in the form of a magnetic ore, with the two main types being ***Magnetite*** also called *Iron Oxide (FE_3O4)* and ***Lodestone***, also called *Leading Stone*.
- If these two natural magnets are suspended from a piece of string, they will take up a position in-line with the Earth's magnetic field always pointing north.
- A good example of this effect is the needle of a compass.
- For most practical applications these natural occurring magnets can be disregarded as their magnetism is very low and because nowadays, man-made artificial magnets can be produced in many different shapes, sizes and magnetic strengths.

Magnetic Materials

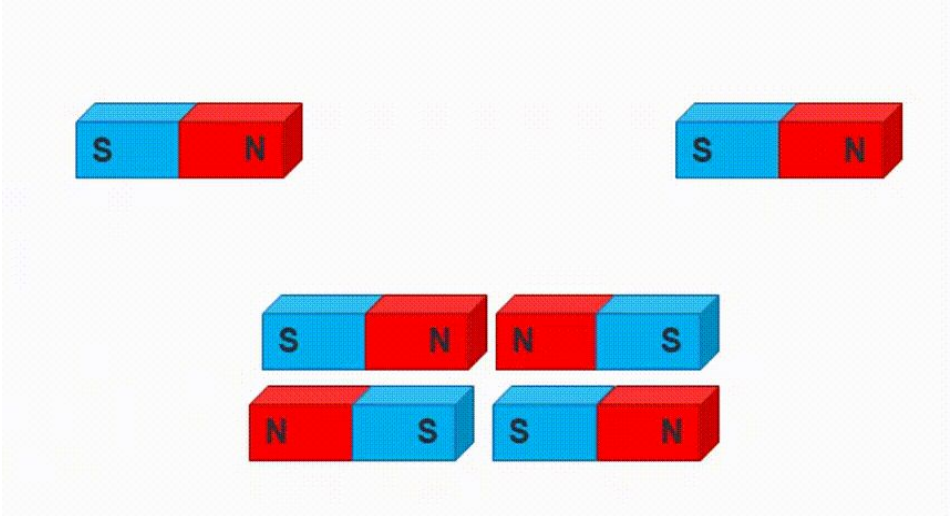
- A magnet is an object that exhibits magnetic properties such as -
  - exerting an attractive force on iron or other magnetic materials
  - exerting both attractive and repulsive forces on other magnets
  - deflecting the path of a moving charged particle
- Magnets are classified as permanent magnets and temporary magnets.
- There are many different types of materials available to make magnets such as iron, nickel, nickel alloys, chromium and cobalt and in their natural state.
- However, when mixed or alloyed together with other materials such as iron or aluminum peroxide they become very strong magnets such as alcomax, hycomax, alni and alnico.

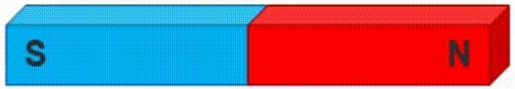




Magnetic pole

- Regions around the bar magnet where the forces are the strongest are called as magnetic poles.
- A bar magnet suspended in Earth's magnetic field orients itself in a north–south direction.
- The north-seeking pole of such a magnet, or any similar pole, is called a north magnetic pole. The south-seeking pole, or any pole similar to it, is called a south magnetic pole.
- Magnetic poles are of two types — north pole and south pole, often abbreviated as N and S.
- Magnetic poles have their pole strength.
- Magnetic poles always occur in north-south pairs called dipoles.
- When a dipole magnet is broken, all of its pieces are also dipoles.





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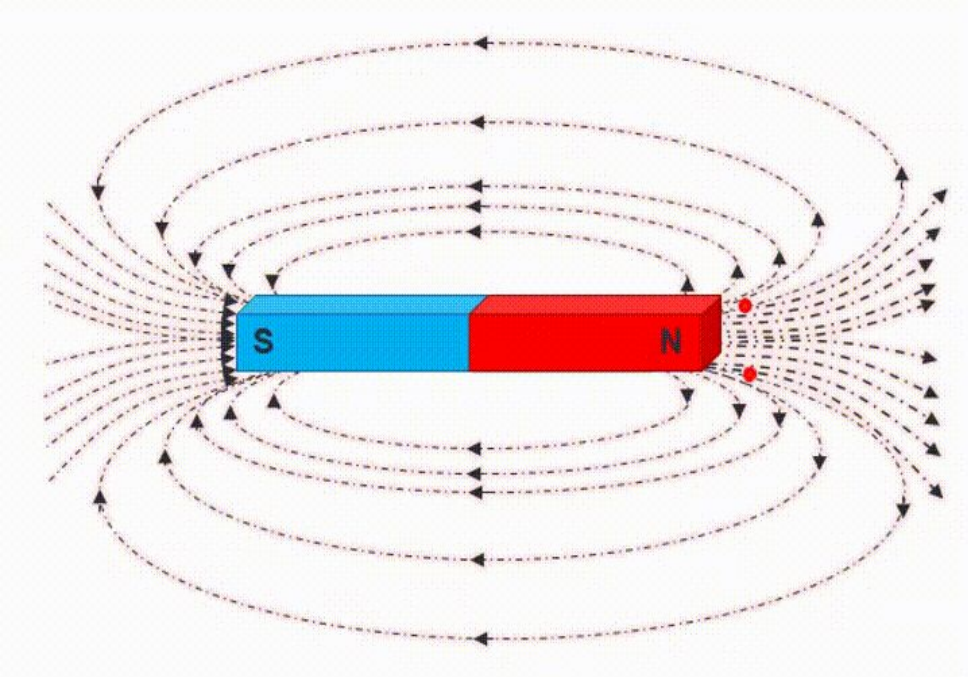
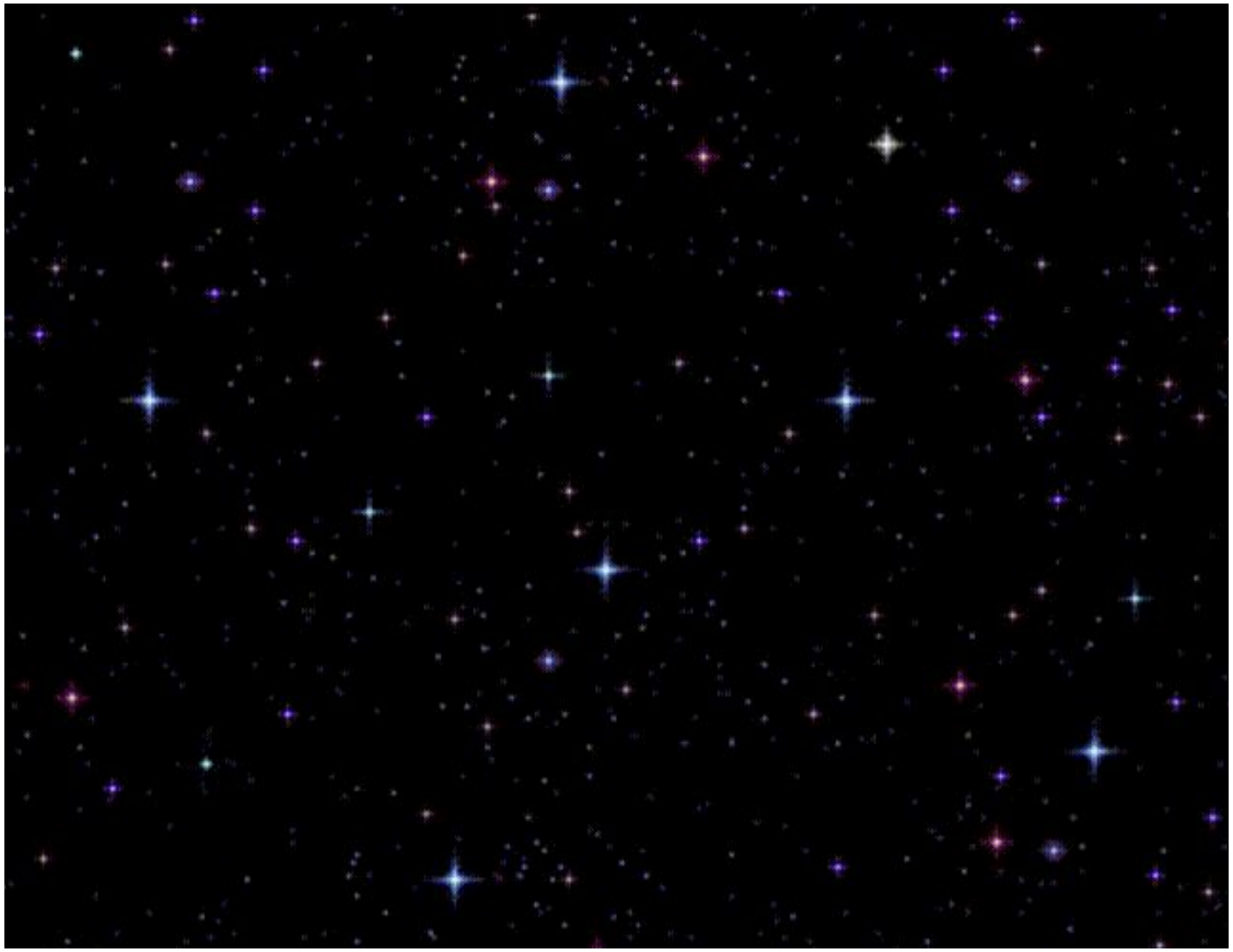


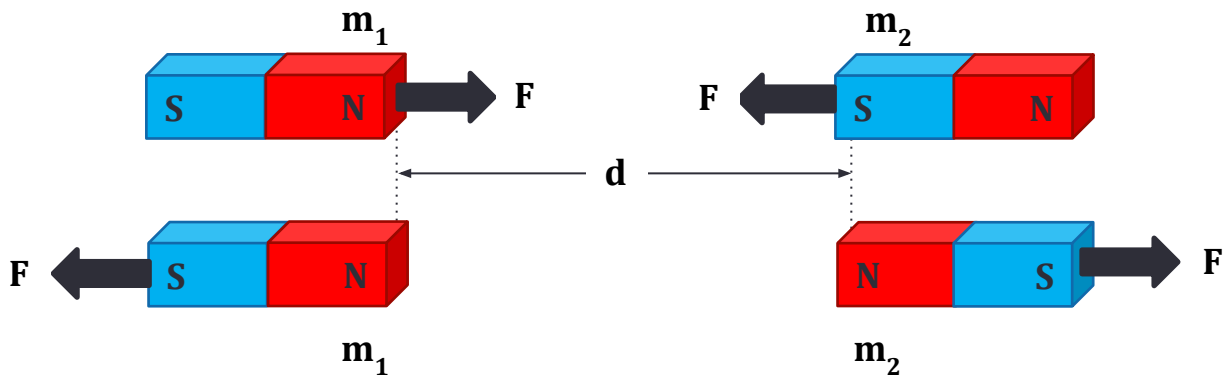
Earth: A Huge Bar Magnet



Coulomb's law of magnetism

- It states that the force (F) of attraction or repulsion between two magnetic poles is
  i. directly proportional to product of magnitude of each magnetic pole or pole strength, [i.e., $F \propto m_1 m_2$] and
  ii. inversely proportional to square of distance between them, [i.e., $F \alpha 1/d^2$]
- From (i) and (ii) above, $F \propto \frac{m_1 m_2}{d^2}$
- $\therefore F = K\frac{m_1 m_2}{d^2} = \frac{\mu}{4\pi}\frac{m_1 m_2}{d^2} = \frac{\mu_0 \mu_r}{4\pi}\frac{m_1 m_2}{d^2}$

  where $\mu = \mu_0 \mu_r$ is called the permeability of medium.



Coulomb's law of magnetism

- As we know $\mathbf{F} = \frac{\mu_0 \mu_r}{4\pi} \frac{m_1 m_2}{d^2}$
- If we substitute valve of μ_0 in F , we get $F = \mu_r \times 10^{-7} \frac{m_1 m_2}{d^2}$
- Now if we consider $m_1 = m_2 = m$ (suppose), $\mu_r = 1$, d = 1 m and $F = 10^{-7}$ N.
- Then, $10^{-7} = 1 \times 10^{-7} \frac{m \times m}{1}$ i.e., $m^2 = 1$
- Thus m = ± 1 weber
- Unit Pole: If two equal or opposite magnetic poles are placed in air at a distance of 1 meter from each other & if they exert a force of 10-7 N on each other, then each pole is said to be of unit pole or one weber.

Attempt Set 1 MCQs

Question No	Question No. 1	Question No. 2	Question No. 3
Statement of Question	The force of attraction or repulsion between two magnetic poles is known as _____.	The number of lines per unit area in a plane perpendicular to the magnetic lines of force.	According to Coulomb's law of magnetism, force (F) between two magnetic poles is directly proportional to -
Level of Question	Remembering	Understanding	Understanding
Option (a)	Newton's first law	magnetic field	m1×m2
Option (b)	Faraday's first law	magnetic flux	d2
Option (c)	Coulomb's first law	magnetic flux density	1/4π
Option (d)	Coulomb's second law	magnetic lines of force	None of the above
Correct Option	**Coulomb's second law**	**magnetic flux density**	**m1×m2**

START

magnetic Field

- Magnetic Field is defined as the space around a unit north pole where force of attraction or repulsion can be observed or felt.
- The symbol for magnetic field is an uppercase, bold **B** (vector notation) or an uppercase, italic *B* (for the magnitude only).
- The magnetic field is also known as the magnetic flux density, and magnetic induction.

magnetic Field Strength & Intensity

- The Magnetic Field Intensity or Magnetic Field Strength is a ratio of the MMF needed to create a certain Flux Density (B) within a particular material per unit length of that material.
- Magnetic field strength: It is defined as the strength of magnetic field developed around a current (I) carrying conductor of length (L).
- It is denoted by H and is given as $\mathbf{H = I/L}$
- Unit of H is A/m
- Magnetic field intensity:
- It is defined as force acting on a unit north pole when placed in a magnetic field.
- It is denoted by H and is given as $\mathbf{H = F/m}$
- Unit of H is N/Wb
- ***NOTE: Magnetic field intensity is magnetic field strength***

magnetic LINES OF FORCE

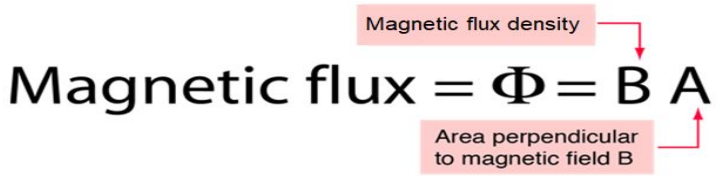
- Magnetic lines of force is defined as the path along which a unit north pole moves when placed in an magnetic field.
- The symbol for magnetic field is an uppercase, bold B (vector notation) or an uppercase, italic B (for the magnitude only).

Properties of magnetic lines of Force

- Magnetic lines of force starts from north pole and ends to south pole.
- Magnetic lines of force have a definite DIRECTION from North to South.
- Magnetic lines of force never intersect each other.
- Magnetic lines of force always form individual CLOSED LOOPS around the magnet.
- The strength of the magnetic field at any location is proportional to the density of the lines drawn.
- Magnetic lines of force that are close together indicate a STRONG magnetic field.
- Magnetic lines of force that are farther apart indicate a WEAK magnetic field.

magnetic flux & Magnetic Flux Density

- Magnetic flux:
- Magnetic Flux is defined as total number of magnetic lines of force starting from a unit north pole.
- It is denoted by Φ and is given as Φ = m
- Its unit is weber (Wb)



- Magnetic flux density:
- Magnetic flux density is defined as total number of magnetic lines of force passing through a surface area.
- It is denoted by B and is given as **B= Φ/A**
- Its SI unit is tesla [T].

magnetic flux density

- Magnetic flux density is denoted by B and is given as $\mathbf{B} = \Phi/\mathbf{A}$
- The SI unit of magnetic flux density is the tesla [T].
- In terms of other units, the tesla is also written as N/Am (from the Lorentz force law),
- Wb/m2 (from Faraday's law), or
- kg/A-s2 (in fundamental units)
- Other than Tesla other unit for magnetic flux density are $\mathrm{T} = \frac{\mathrm{N}}{\mathrm{Am}} = \frac{\mathrm{Wb}}{\mathrm{m}^2} = \frac{\mathrm{kg}}{\mathrm{As}^2}$

Application of MAGNETISM

- We come across magnets in various forms such as computers, MRI machines or inside some appliances which are used in the house, business or medical industry. The size can be from very small to the large giant like structures. Some magnet uses at home, in the laboratory and in daily life is provided in the points below.
- We might be using computers in our day to day lives but never wondered the presence of a magnet inside it. Magnetic elements present on a hard disk helps to represent computer data which is later ‘read’ by the computer to extract information.
- Magnets are used inside TVs, Sound speakers and radios. The small coil of wire and a magnet inside a speaker transforms the electronic signal to sound vibrations.
- Magnets are used inside a generator to transform mechanical energy to electrical energy where there are other kinds of motors which use magnets to change electrical energy to mechanical energy.
- Electrically charged magnets can help cranes to move large metal pieces.
- Magnets are used in filtering machines which separates metallic ores from crushed rocks.
- It is also used in food processing industries for separating small metallic pieces from grains etc.

Application of MAGNETISM

- Magnets are used in MRI machines which are used to create an image of the bone structure, organs, and tissues. Even magnets are used to cure cancer.
- At home, you use magnets when you stick a paper on the refrigerator in order to remember something. Attaching a magnetic bottle opener to the fridge can come in handy.
- We often use pocket a compass to find out directions when we are on a trek. The pocket compass uses a magnetic needle to point north.
- The dark strip on the back of debit and credit cards is of magnetic nature and are used to store data just like computers' hard drives.
- Magnets can help collect all the nails which are scattered on the ground after a repair job.

Attempt Set 2 MCQs

Question No	Question No. 1	Question No. 2	Question No. 3
Statement of Question	____is defined as the space around a unit north pole where force of attraction or repulsion can be felt.	Magnetic field intensity is denoted by symbol	Unit of magnetic flux density (B) is
Level of Question	Remembering	Understanding	Understanding
Option (a)	Magnetic Field	φ	Wb
Option (b)	Magnetic Flux	H	T
Option (c)	Both (A) and (B)	B	A/m
Option (d)	None of the above	M	N/Wb
Correct Option	**Magnetic Flux**	**H**	**T**

START