Study Material

Program Code: All Program

Semester: First

Course Name: Basic Science (Physics)

Course Code: 22102

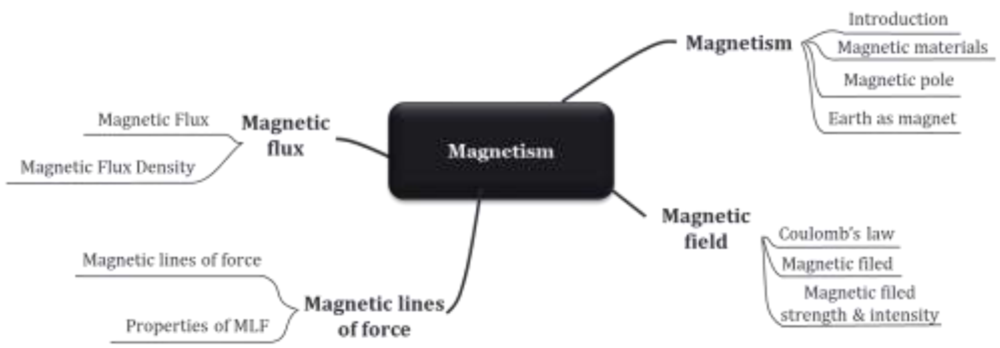
Topic Name: Electricity, Magnetism & Semiconductors

UO2b: Describe the concept of given magnetic intensity and flux with relevant units.

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

Course Expert: S. K. Rawat	**Date: 25/08/2020**

Concept Map:



Key words: Magnetic field, magnetic field intensity, magnetic flux, magnetic flux density

Key Questions:

1. What are magnetic field and magnetic lines of force?
2. What are properties of magnetic lines of force?
3. What are the applications of coulomb's law of magnetism?

Key Definition:

1. A quantity corresponding to the amount of magnetic flux originating from a given magnetic pole is called magnetic pole.
2. The attraction or repulsion between magnetic poles is magnetic force.
3. 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.
4. It is defined as the space around a unit north pole where force of attraction or repulsion can be observed or felt.
5. Magnetic lines of force are defined as the path along which a unit north pole moves when placed in a magnetic field.
6. Magnetic Flux is defined as total number of magnetic lines of force starting from a unit north pole.
7. Magnetic flux density is defined as total number of magnetic lines of force passing through a surface area.
8. Magnetic field strength is defined as the strength of magnetic field developed around a current (I) carrying conductor of length (L).
9. Magnetic field intensity is defined as force acting on a unit north pole when placed in a magnetic field.

Formula:

1. Magnetic force F = $\frac{\mu_0\mu_r}{4\pi}\frac{m_1m_2}{d^2}$
2. Magnetic flux density $\mathbf{B} = \Phi/\mathbf{A}$
3. Magnetic flux density $\mathbf{H} = I/L$
4. Magnetic field intensity $\mathbf{H} = \mathbf{F}/\mathbf{m}$

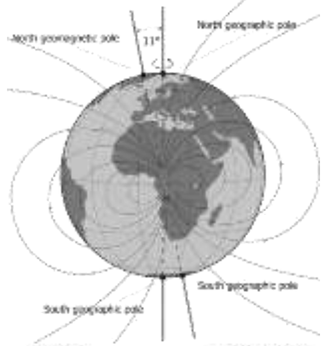
Notes

Introduction

The ancient Greeks knew that a type of rock with magnetic properties known as lodestone or magnetite attracted iron. The compass, an important device for navigation, has a suspended magnet which aligns parallel to the magnetic field produced by the Earth and as a result points to the North Pole.

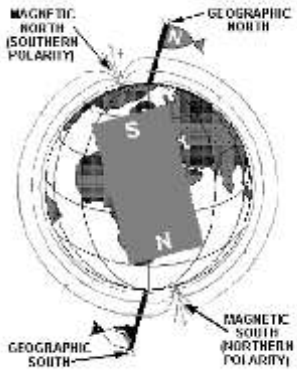
Properties of Magnets

A magnet has the property of attracting iron and steel (ferromagnetic materials). When the magnet is suspended so that it can rotate freely it always settles pointing approximately geometrically north and south.



The magnetic compass needle always aligns itself in a particular direction, regardless of its location on earth, indicates that the earth is a huge natural magnet.

The magnetic axis of the earth is located about 15° from its geographical axis thereby locating the magnetic poles some distance from the geographical poles.



The ability of the north pole of the compass needle to point toward the north geographical pole is due to the presence of the magnetic pole nearby. This magnetic pole is named the magnetic North Pole.

We know the north pole of a compass needle (a small bar magnet) can be attracted only by an unlike magnetic pole, that is, a pole of south magnetic polarity.

Magnet

A magnet is an object that exhibits magnetic properties such as -

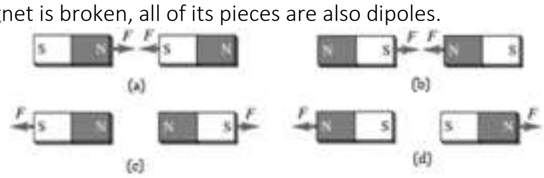
- exerting an attractive force on iron or other magnetic materials
- exerting both attractive and repulsive forces on other magnets
- deflecting the path of a moving charged particle

Magnetic Poles

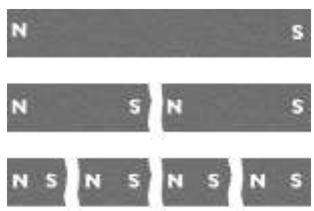
A quantity corresponding to the amount of magnetic flux originating from a given magnetic pole is called magnetic pole.

- Regions on a magnet where the forces are the strongest are called magnetic poles.
- Magnetic poles are of two types: North Pole and South Pole often abbreviated as N and S.
- They have their pole strength.
- Magnetic poles always occur in north-south pairs called dipoles.
- Combinations of dipoles are called multipoles.
- Magnetic monopoles do not exist. When a dipole magnet is broken, all of its pieces are also dipoles.

Experiments shows that unlike poles attract and like poles repel (similar to electric charges).
Poles cannot exist independently (unlike electric charges).



Every magnet has a north and south pole. If you break a magnet in half each half will still behave like a complete magnet with both north and south poles, no matter how many times you break it in half there will never be a single pole, even when your piece is one atom thick there are two poles.



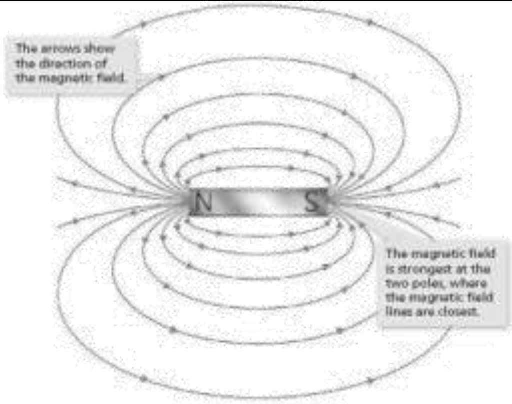
Magnetic Force

The attraction or repulsion between magnetic poles is magnetic force.

A force is a push or a pull that can cause an object to move.

A magnetic force is produced when magnetic poles interact.

A magnetic force is strongest at the poles of a magnet, but it is not limited to the poles. Magnetic forces are exerted all around a magnet.



Coulomb's law of Magnetism

It states that the force (F) of attraction or repulsion between two magnetic poles is

- directly proportional to product of magnitude of each magnetic pole or pole strength, [i.e., $F \propto m_1 m_2$] and
- 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.

As we know 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 = $\mu_r \times \frac{m_1 m_2}{d^2}$

Now if we consider $m_1 = m_2 = m$ (suppose), $\mu_r = 1$, d = 1 m and F = 10^{-7} N.

Then, $m^2 = 1$ Thus **m = ± 1 weber**

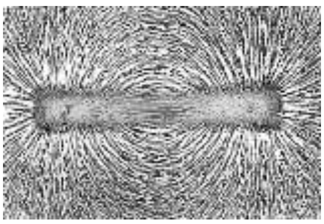
Unit Pole: If two equal or opposite magnetic poles are placed in air at a distance of 1 meter from each other & if they exert a force of 10^{-7} N on each other, then each pole is said to be of unit pole or one weber.

Magnetic Field

It 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 lines of force

Magnetic lines of force are defined as the path along which a unit north pole moves when placed in a magnetic field.



Properties of magnetic lines of Force

1. Magnetic lines of force start from North Pole and ends to South Pole.
2. Magnetic lines of force have a definite DIRECTION from North to South.
3. Magnetic lines of force never intersect each other.
4. Magnetic lines of force always form individual CLOSED LOOPS around the magnet.
5. The strength of the magnetic field at any location is proportional to the density of the lines drawn.
6. Magnetic lines of force that are close together indicate a STRONG magnetic field.
7. Magnetic lines of force that are farther apart indicate a WEAK magnetic field.

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 $\mathbf{B} = \Phi/\mathbf{A}$
Its SI unit is 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 T = N/Am = Wb/m^2 = kg/As^2

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 $\mathbf{H} = \mathbf{F}/\mathbf{m}$
Unit of H is N/Wb

NOTE: Magnetic field strength and magnetic field intensity is same.

Applications
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.
- 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.

Link to YouTube/ OER/ video/e-book:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
2. https://byjus.com/physics/uses-of-magnets/
3. https://www.cliffsnotes.com/study-guides/physics
4. https://openpress.usask.ca/physics155/chapter/8-magnetic-forces-and-fields/

Key Take away:

1. Concept of Magnetic field, Magnetic field intensity.
2. Theory of magnetic flux and magnetic flux density.
3. Application of Magnetism.

Formative Assessments

<22102> : <All Program> : < All Program >: <Electricity, Magnetism & Semiconductors>: <UO2b> : <LO3> : <Assessments> : <Formative>

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Assessment Type: Formative Assessments: Embedded questions in video/ PPT

Set 1		
Question No 1	Question No 2	Question No 3
The force of attraction or repulsion between two magnetic poles is inversely proportional to the square of the distance between them. This 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) of attraction or repulsion between two magnetic poles is directly proportional to -
Remembering	Understanding	Understanding
a) Newton's first law	a) magnetic field	a) m1×m2
b) Faraday's first law of electromagnetic induction	b) magnetic flux	b) d^2
c) Coulomb's first law	c) magnetic flux density	c) 1/4π
d) Coulomb's second law	d) magnetic lines of force	d) None of the above
Ans: <Coulomb's second law >	Ans: < magnetic flux density >	Ans: < m1×m2>

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

Practice Worksheets

<22102> : <All Program> : < All Program >: <Electricity, Magnetism & Semiconductors>: <UO2b> : <LO3> : <Assessments> : <Formative>

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A. The number of lines per unit area through any substance in a plane at right angles to the lines of force is called a) magnetic flux b) magnetic flux lines c) magnetic flux density d) magnetic flux intensity	B. According to Coulomb's 2nd law, the force between two magnetic poles separated by a distance is ___________ a) directly proportional to product of the magnitude of two pole b) inversely proportional to square of distance between the two poles c) Both (A) and (B) d) None of the above
Ans A:	Ans B:
C. What do you call a pole that when place in air with a similar and equal pole will cause a force of repulsion of $(1/4\pi)\mu_o$ Newtons? a) South pole b) Unit pole c) Convergence pole d) Universal pole	D. What is the unit of magnetic flux in SI system? a) Weber b) Maxwell c) Tesla d) Gauss
Ans C:	Ans D:
E. A magnet is an object that exhibits magnetic properties such as. a) exerting an attractive force on iron or other magnetic materials b) exerting both attractive and repulsive forces on other magnets c) deflecting the path of a moving charged particle d) all of the above	F. In the expression $\mu=\mu0 \times \mu r$, μ is called____________. a) permeability of medium b) permeability of free space c) permeability of vaccum d) all of the above
Ans E:	Ans F:
G. Magnetic lines of force that are farther apart indicate a _______________ magnetic field. a) Weak b) Strong c) Normal d) None of the above	H. Which is the correct unit of magnetic flux density (B)? a) T b) N/Am c) Wb/m2 d) all of the above
Ans G:	Ans H: