STUDY ON MAGNETIC FIELD AND MAGNETIC FORCE

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ABSTRACT

What happens when we bring an iron nail to a bar magnet? Why does an iron nail stick to the bar magnet? Well, this is all because of force of attraction. This force is apply by the magnet to the nail and is known as MAGNETIC FORCE. Is contact force is necessary for this force? Contact force is not necessary for the magnetic force. This contact force tells us there is an invisible field which we cannot experience but it, exist. This field is produce by a magnet hence we call it magnetic field. Strength of the field is greater closer to the magnet and decreases as we go further away from it.

KEYWORD- Magnetic field (B),Magnetic force, Magneto statics,Lorentz force,Ampere's law,Gyroscopic forces

Introduction-

Basic properties of magnet- These are as follows:

Attractive property- A magnet attracts small piece of iron, nickle, Cobalt etc. Directive property- A freely suspended magnet align itself nearly in the geographic North south direction. Like poles repel and unlike poles attract- This is fundamental law of magnetic poles.Magnetic poles exist in pairs- isolated magnetic poles do not exist. If we break a magnet into two pieces, we get two similar dipole magnet.

As we know stationary charges produce ELECTRIC FIELD.

$$E(r) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_1}{r_i^2}$$

What happen when a charge moves? A moving charge produces MAGNETIC FIELD. It is denoted by B(r). Again it is vector field. Let us consider a point charge Q moving with the velocity v, located at rat a given time t in the presence of both the electric and magnetic field. The force on an charge Q due to both electric and magnetic field is given by-

$$F = Q[E(r) + v \times B]$$

$$F = F_{electric} + F_{magnetic}$$

This force was given by H.A. Lorentz, so it is called Lorentz force.

There are following features are as follows-

1- F, v, B (force, velocity, and magneticfield) is perpendicular to each other then the motion of the particle in magnetic field is circular.
2- F, v, B (force, velocity, magnetic field) is not perpendicular to each other then the motion of particle have helix motion.(spin type motion)

A current carrying wire produces a magnetic field around it. On the other hand, no magnetic field is associated with a wire that carries no current. The source of electric field is an electric charge. The source of magneticfield is not a magnetic charge. Instead, moving electric charge produces magnetic field.

METHODOLOGY-

CURRENTS – The current in a wire is the charge per unit time.

1 Amperes = 1 $^{Coulombs}/_{Second}$.

BIOT- SAVART LAW- According to this law the magnetic field due to current element dl and carrying current I at a point at a distance and the relation between current and magnetic field is given as:

$\delta B \ \alpha \ \frac{I\ \delta l\ sin\theta}{r^2}$

$\delta B = \mu_0 \ \frac{I\ \delta l\ sin\theta}{4\pi r^2}$

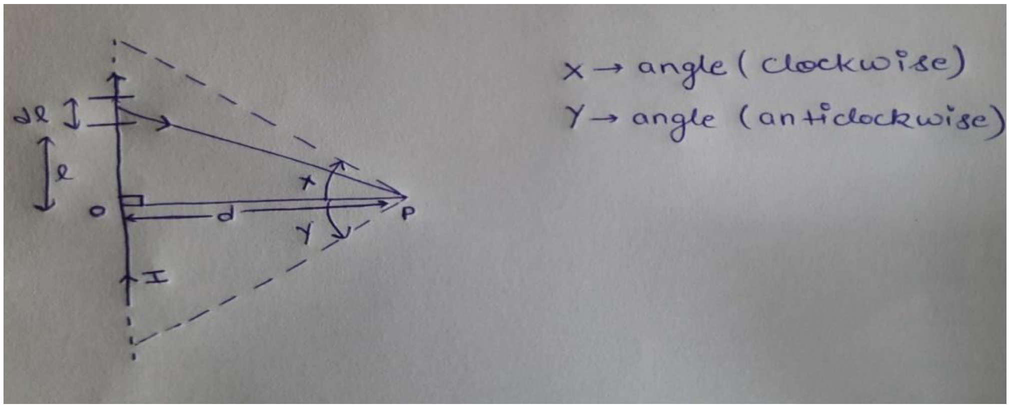
Where, $\mu_{0=}$ permeability of free space (for vacuum)

Magnetic force do not any work (dw =0). Magnetic force may alter the direction in which particle moves but they cannot speed it up and slow it down. The fact that magnetic force does not do any work is an elementary and direct consequence of Lorentz force law. Magnetic force is Gyroscopic force. Gyroscopic force = Power should be zero velocity depends on force and work done equal to zero. POWER = 0.

Direction of the magnetic field is denoted by cross and dot. Dot(·) represents the direction outside the plane of paper where cross(×) represent the direction inside the plane of paper. Right hand thumb rule states that If we hold the straight conductor in the grip of our right hand in such a way that the extended thumb points in the direction of current, then the direction of the curl of the fingers will give the direction of the magnetic field.

- Magnetic field (B) due to circular coil carrying current (At centre)-$\vec{B} = \mu_0 \ \frac{NI}{2a} \widehat{\emptyset}$ (for N cycle)
- Magnetic induction due to current in a straight conductor-

B $= \mu_0 \frac{I}{4\pi d}(\sin X + \sin Y)$



- Magnetic field due to Solenoid-
  B = □$_0$ □□
  Here, n-number of turns per meter length

MAGNETIC MOMENT- Any current carrying loop is called MAGNETIC DIPOLE. □ = m × 2□

Where, □ =magnetic moment

2□= Length of the bar magnet

AMPERE'S LAW-This law states that the line integral of the magnetic field around any closed circuit is equal to ∇ × □ =□$_0$ □ Is known as Ampere's law (in differential form). Where, J is volume charge density.

VECTOR POTENTIAL(A)-

∇. □ = 0 Invites the introduction of a vector potential (A) in magnetostatic: B = ∇ × □

MODELING AND ANALYSIS-

MAGNETOSTATIC BOUNDARY CONDITION-

- - = 0

(Perpendicular component of B is continuous)

- - =k

(Parallel component of B is discontinuous)

- = 0
- - = -k

The basic difference between magnetic field and electric field is magnetic field lines of magnet form Continuous closed loops and directed from N to S pole outside the magnet and S to N pole inside the magnet and forms closed loops while in the case of an electric dipole the field lines begin from positive charge and end on negative charge or escape to infinity.

POINTS OF SIMILARITY-

Both fields depend inversely on the square of the distance from the source. Both are long range fields. The principle of superposition is applicable to both fields.

POINTS OF DIFFERENCE-

The magnetic field is produced by a vector source. The electrostatic field is produce by a scaler source. In Biot-savart law,the magnitude of the magnetic field is proportional to the sine of the angle between current and displacement vector while there is no such angle dependence in Coulomb's law for the electrostatic field. The direction of the electrostatic field is along the displacement vector joining the source and the field point. The direction of the magnetic field is perpendicular to the plane containing the displacement vector and current.

Electrostatics:	Coulomb -	gauss
Magneto statics:	Biot- Savart -	ampere

RESULTS AND DISCUSSION

ESSENTIAL TERMS: -

Magnetic permeability(μ)-It is property of material to pass magnetic force of lines.

$\square_{\square} = \frac{\square}{\square_0} = \frac{\square}{\square_0}$ Where, $\square_0$ - magnetic field strength in vacuum

1) Intensity of magnetization($\vec{\square}$)- It is the ratio of magnetic moment per unit volume of a magnetic material. $\vec{\square} = \frac{\vec{\square}}{\square}$ amp × meter
2) Magnetizing field (H)- It is the magnetic field used for magnetization of a material. H= nI(Its unit is amp×meter)
3) Magnetic susceptibility ($\square_{\square}$)- It is ratio of magnetization per unit magnetizing field. $\square_{\square} = \frac{\square}{\square}$

Magnetic field is minimum or zero along the axis of current element and magnetic field is maximum in a plane passing through the element and perpendicular to it's axis. Since a magnetic field exerts force perpendicular to the direction of motion of the charged particle,no work is done on the charge particle, means work done is zero and stationary charge does not produc any magnetic field.

CONCLUSION-

Magnets are widely uses in refrigerator, freezer, earphones and etc. magnets are also use to store data in computers .What makes a material magnetic?

Answer is magnetic domains. An atom has electrons and electrons are tiny magnets. They have S-pole and N- pole too. As they spin around the axis they generates magnetic field. In the non- magnetic material magnetic field is created by the electrons which cancel out each other. But in magnetic material atoms form small group call domain, in each domain electron share the same magnetic orientation. These domains make it easy for a material to be magnetized. When enough domains are aligned it becomes magnet. There are two type of magnets permanent magnets and temporary magnets. Temporary magnet is made up of iron or nickel. A permanent magnet is made up of steel.

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