DRGP Institute

Chapter 4

Moving Charges and Magnetism

Chapter 4
Moving Charges and Magnetism

BOARD - 2013

1. Show the direction of magnetic field in form of ⊙ & ⊗ at point P.

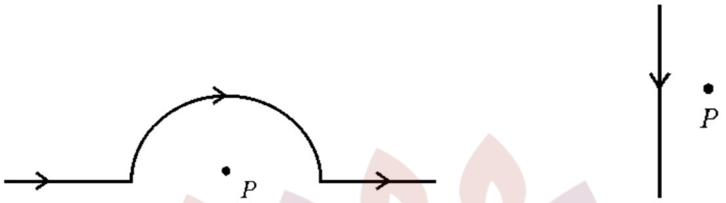
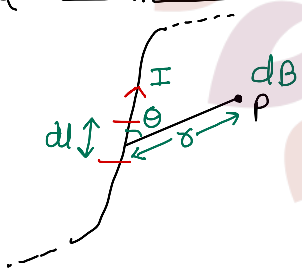


Fig. A   Fig. B

⇒ Fig. A ⇓ ⊗   Fig. B ⇓ ⊙

2. (i) write Biot-Savart Law.
   (ii) write the path of motion of electron when it enters in magnetic field at - (A) perpendicular (B) at θ.

⇒ (i) Biot-Savart Law -



According to this law, produced magnetic field at a point P(r, θ) due to current element (Idl) -
  (i) directly proportional to current
  (ii) directly proportional to length
  (iii) inversely proportional to square of distance from conductor
  (iii) directly proportional to sine of angle.

$$dB \propto I$$
$$dB \propto dl$$
$$dB \propto \sin\theta$$
$$dB \propto \frac{1}{r^2}$$

$$dB \propto \frac{I dl \sin\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2}$$

vector form -

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I \, \vec{dl} \times \vec{r}}{r^3}$$

$\left\{ \hat{r} = \frac{\vec{r}}{r} \right\}$

(ii) Path ⇒ (a) $\theta = 90^\circ$ ⇒ Circular path
(b) at θ ⇒ Helical motion
(Circular + Translatory)

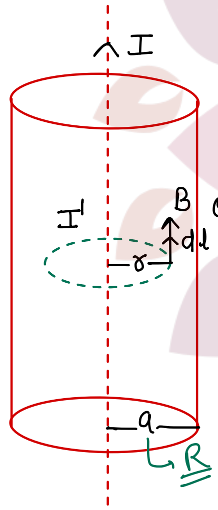
3. Write Ampere's Circuit Law.
A long straight wire of a circular cross section (radius a) carrying steady current. Current is uniformly distributed in the wire. Calculate magnetic field inside the region ($r<a$) in the wire.

⇒ A. Ampere's Law - Line integral of the magnetic field surrounding close loop equals μ_0 times of total current passing through this loop -

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \Sigma I$$

$$\oint B\,dl\cos\theta = \mu_0 \Sigma I$$

B. Magnetic field due to Long current Carrying Cylindrical Conductor



Let we have a current carrying wire of Radius (a). Current (I) is flowing it. To Calculate Magnetic field. we assume amperian loop of radius (r).

$r<a$ (R)

According to Ampere's Law -

$$\oint B\,dl\cos\theta = \mu_0 \Sigma I$$

$$\oint B\,dl\cos 0^\circ = \mu_0 I' \quad -(1)$$

Calculation of I'

Current passing through $\pi R^2 = I$
Current passing through $1\,m^2 = I/\pi R^2$
Current passing through $\pi r^2 = \frac{I}{\pi R^2} \times \pi r^2 = \frac{I r^2}{R^2}$

put in eq^n (1)

$$\oint B\,dl = \mu_0 \left(\frac{I r^2}{R^2}\right)$$

$$B\oint dl = \frac{\mu_0 I r^2}{R^2}$$

$$B(2\pi r) = \frac{\mu_0 I r^2}{R^2}$$

$$\boxed{B = \frac{\mu_0 I r}{2\pi R^2}}$$

BOARD- 2013 (SUPP.)

4. write ampere's circuit Law. Draw the diagram which shows the magnetic field produced by a current carrying solenoid and derive an expression for magnetic field on its axis.

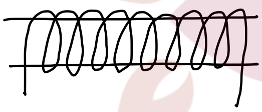
⇒

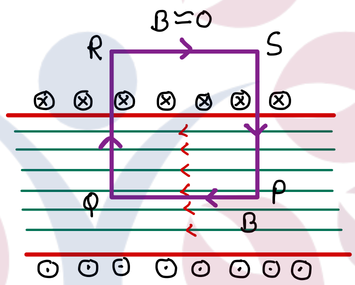
Ampere's Law - Line integral of the magnetic field surrounding close loop equals μ_0 times of total current passing through this loop -

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \Sigma I$$

$$\oint B\,dl\cos\theta = \mu_0 \Sigma I$$

Solenoid - A long cylindrical tube whose radius is negligible in comparison to its length and insulated copper wire is wound along its length, then arrangement is known as a solenoid.





→ Let a solenoid of radius R & Length L, whose length is very Large than its radius. There are n turns per unit Lenth and Current I is flowing through it. Let B is magnetic field produced by it.

→ Let us imagine a rectangular closed path PQRS.

According to Ampere's Law -

$$\int_{PQRS} \vec{B}\cdot\vec{dl} = \mu_0 \Sigma I$$

$$\int_{PQ} B\,dl\cos\theta + \int_{QR} B\,dl\cos\theta + \int_{RS} B\,dl\cos\theta + \int_{SP} B\,dl\cos\theta = \mu_0 \Sigma I$$

PQ	QR	RS	SP
↓	↓	↓	↓
$\theta = 0^\circ$	$\theta = 90^\circ$	$B = 0$	$\theta = 90^\circ$
$\cos 0 = 1$	$\cos 90^\circ = 0$		$\cos 90 = 0$

$$B\int_{PQ} dl = \mu_0 \Sigma I$$

$$Bl = \mu_0 n l i$$

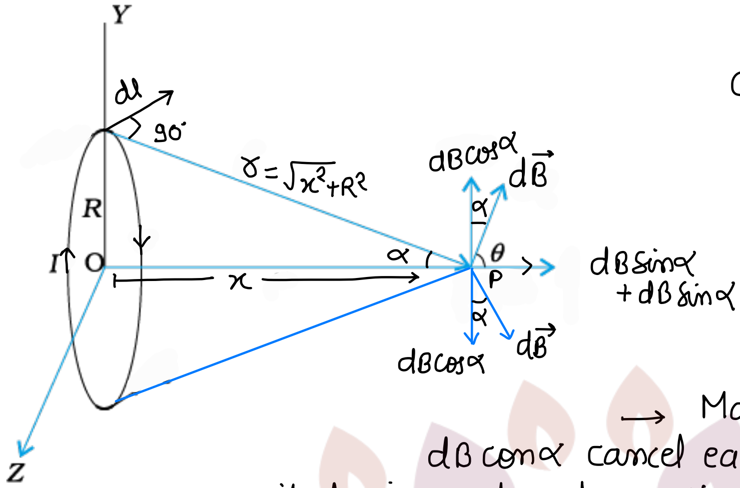
{ no. of turns per unit length = n
no. of turns on l length = ln
Total current = nli

$$\boxed{B = \mu_0 n i}$$

or $B = \mu_0 \frac{N}{L} i$

5. Write Biot-Savart Law. Derive an expression for magnetic field on the axis of current carrying circular coil. Draw Necessary diagram.

⇒



Let we have a current Carrying circular loop of Radius R. At point P Situated on axis of loop at distance x from center of loop. Angle b/w $\vec{R}$ & dl is 90°. So, $\sin\theta = \sin 90 = 1$.

⟶ Magnetic field component dB cosα cancel each other because their magnitude is equal and opposite. Resultant B is due to dB sinα.

$$B = \int_0^{2\pi r} dB \sin\alpha$$

$$B = \int_0^{2\pi r} \frac{\mu_0}{4\pi} \frac{I dl \sin 90^\circ}{r^2} \sin\alpha$$

$$B = \int_0^{2\pi R} \frac{\mu_0}{4\pi} \frac{I dl}{r^2} \left(\frac{R}{r}\right)$$

$$B = \frac{\mu_0 I R}{4\pi r^3} \int_0^{2\pi R} dl$$

$$B = \frac{\mu_0 I R}{4\pi r^3} [l]_0^{2\pi R}$$

$$B = \frac{\mu_0 I R}{4\pi r^3} [2\pi R]$$

$$B = \frac{\mu_0 I R^2}{2 r^3}$$

$$B = \frac{\mu_0 I R^2}{2[\sqrt{x^2+R^2}]^3}$$

$$B = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$$

if N number of turns -

$$B = \frac{\mu_0 N I R^2}{2(x^2+R^2)^{3/2}}$$

At centre $x=0$

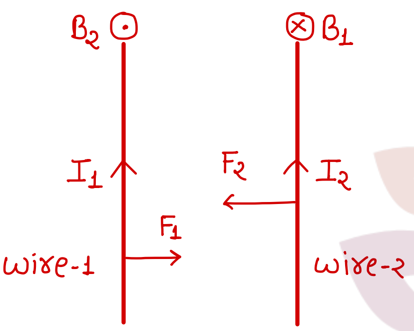
$$B = \frac{\mu_0 N I R^2}{2R^3}$$

$$\boxed{B = \frac{\mu_0 N I}{2R}}$$

BOARD - 2014

6. Derive expression for the force per unit length acting on the two straight parallel current carrying conductors. In which condition will this force be attractive and repulsive? Define the standard unit of current. [2 + 1/2 + 1/2 + 1 = 4]

⇒ Suppose we have two current carrying wire in which current I_1 & I_2 is flowing, distance b/w both wire is 'd' and both wire experience $\vec{B}$ Magnetic force BIl due to each other.



Force acting on 1st wire -

$$F_1 = B_2 I_1 l_1$$

$$F_1 = \frac{\mu_0 I_2 I_1 l_1}{2\pi d} \qquad \left\{ B_2 = \frac{\mu_0 I_2}{2\pi d} \right\}$$

$$\frac{F_1}{l_1} = \frac{\mu_0 I_2 I_1}{2\pi d} \quad -(1)$$

Force acting on 2nd wire -

$$F_2 = B_1 I_2 l_2$$

$$F_2 = \frac{\mu_0 I_1 I_2 l_2}{2\pi d} \qquad \left\{ B_1 = \frac{\mu_0 I_1}{2\pi d} \right\}$$

$$\frac{F_2}{l_2} = \frac{\mu_0 I_1 I_2}{2\pi d} \quad -(2)$$

So, force acting on wire is different but force acting on per unit length is same -

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

Case 1st :- If current in both wire is same in direction then - Attractive force

Case 2nd :- If current in both wire is opposite in direction then - Repulsive force

Standard unit of 1 Ampere - $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$

if $I_1 = I_2 = 1A$

$d = 1m$

$\mu_0 = 4\pi \times 10^{-7}$ N/A^2

$$\frac{F}{l} = \frac{4\pi \times 10^{-7} (1 \times 1)}{2\pi (1)} = 2 \times 10^{-7} \text{ N/m}$$

" If two parallel current carrying wires are placed at 1m distance in free space & force acting on per unit length of both wire is 2×10^{-7} N/m, then current flowing in both wire, will be 1 Ampere"

BOARD - 2015

7. write ampere's Law. Obtain an expression of magnetic field on the axis of current carrying very long solenoid. Draw necessary diagram. [1 + 2½ + ½ = 4 Marks]

BOARD - 2016

8. A charge q enters ⊥ with the direction of magnetic field $\vec{B}$ with a velocity $\vec{v}$. what would be force acting on this charge. [1 Marks]

⇒ $F = qvB\sin\theta$

$F = qvB\sin 90°$

$\boxed{F = qvB}$

9. Determine the force acting b/w two parallel current carrying conductor wires. Define Ampere. [2+1 = 3Marks]

BOARD - 2017

10. write the name of fields produced by a moving charged particles.

⇒ Magnetic field & Electric field.

11. Biot-Savart law & Current carrying circular Loop.
12. Ampere Law & Solenoid.

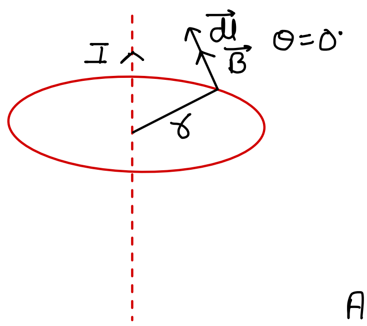
BOARD - 2017 (Supp.)

13. Biot-Savart law & Current carrying circular Loop.
14. Ampere Law & Solenoid.

BOARD - 2018

15. obtain expression of magnetic field due to current carrying straight conductor using Ampere's Law. [2 Marks]

⇒



Suppose there is a current carrying conductor of ∞ length. Current I is flowing through in it. To calculate magnetic field we assume a circular amperian loop around wire of radius small r.

According to Ampere's Law -

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \Sigma I$$

$$\oint B\,dl\cos\theta = \mu_0 \Sigma I$$

$\theta = 0^\circ \qquad \Sigma I = I$

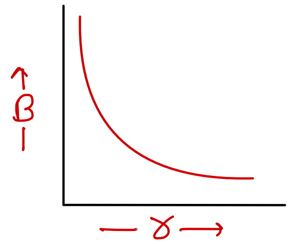
$\cos 0^\circ = 1$

$$\oint B\,dl = \mu_0 I$$

$$B \oint dl = \mu_0 I$$

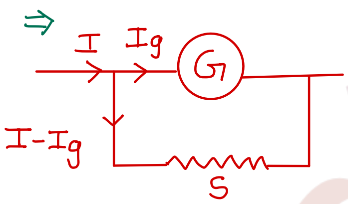
$$B(2\pi r) = \mu_0 I$$

$$\boxed{B = \frac{\mu_0 I}{2\pi r}}$$



16. The resistance of a galvanometer is $99\,\Omega$. The necessary current for full scale deflection is 1mA. If a shunt of $1\,\Omega$ is connected with galvanometer then find the value of maximum current which can be measured by this galvanometer. [2 Marks]

⇒



$$I_g G = (I - I_g) S$$

$$I - I_g = \frac{I_g G}{S}$$

$$I = \frac{I_g G}{S} + I_g$$

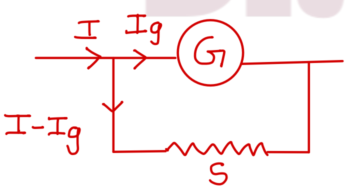
$$I = \frac{1 \times 10^{-3} \times 99}{1} + 1 \times 10^{-3}$$

$$I =$$

BOARD-2018 (Supp)

17. How a moving coil galvanometer is converted into an ammeter?

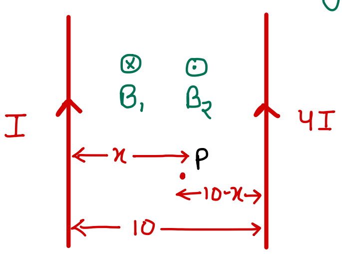
⇒



By joining a shunt resistance of very less value in parallel combination with Galvanometer.

18. Two long current carrying conductor wires are placed parallel to each other at a distance of 10cm. If I & $4I$ current are passing through them in same direction then find the position of the point where resultant magnetic field is zero due to wires. [2 Marks]

⇒



$$B = \frac{\mu_0 I}{2\pi d}$$

at P point ⇒ Resultant Magnetic field $= 0$

so $B_1 = B_2$

$$\frac{\mu_0 I}{2\pi x} = \frac{\mu_0 (4I)}{2\pi(10-x)}$$

$$\frac{1}{x} = \frac{4}{(10-x)}$$

$$10-x = 4x$$

$$5x = 10$$

$$\boxed{x = 2cm}$$

from wire-1 2cm
and from wire-2 8cm.

19. Derive the formula to find magnetic field inside a long current carrying cylindrical conductor. With the help of Amperes Law. [2 Marks]

BOARD-2019

20. Write formula for force on a current carrying conductor in a magnetic field. [1 Marks]

⇒ $\vec{F} = I(\vec{l} \times \vec{B})$

$F = BIl \sin\theta$

21. Write Ampere's Law. Draw a diagram and derive an expression for magnetic field due to an infinitely long straight current carrying conductor at any point.

BOARD-2020

22. Prove that current flowing in the coil of galvanometer is directly proportional to the deflection generated in the coil.

⇒ When current flows in galvanometer coil, coil of galvanometer deflects.

Restoring force ∝ Angle of deflection

$$\tau \propto \phi$$

$$\tau = C\phi \quad \text{—①} \quad \{C = \text{Twist constant}\}$$

W.K.T

$$\tau = BINA\sin\theta$$

{ $\sin\theta = \sin 90^\circ = 1$
due to radial magnetic field }

$$\tau = BINA$$

put in Eqⁿ ①

$$BINA = C\phi$$

$$I = \frac{C}{BNA}\phi$$

$$I = K\phi \qquad \{K = C/BNA\}$$

$I \propto \phi$

This is principle of galvanometer

BOARD- 2020 (SUPP.)

23. Write the formula of Biot-Savart's Law in vector form. Derive an expression of magnetic field on the axis of a current carrying circular coil. Draw necessary diagram.

BOARD- 2021

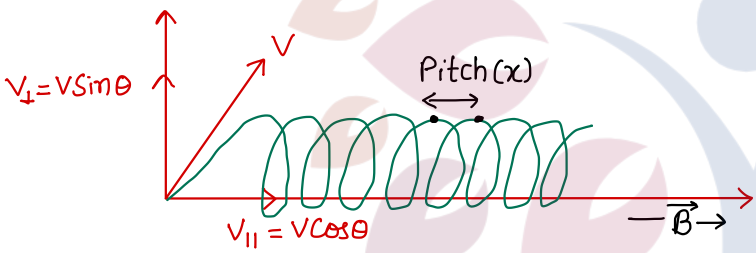
24. The current required for unit deflection in galvanometer is called-

A. Current sensitivity B. Voltage sensitivity

C. Figure of Merit D. Reduction factor

Answer - A.

25. Write Ampere's Law in mathematical form. A charged particle is in motion, making an angle θ (0°<θ<90°) with uniform magnetic field. Obtain the formula for its time period and pitch. Draw necessary diagram.



Suppose we have a charged particle of charge q, moving with velocity V in magnetic field B. Angle b/w velocity & magnetic field is θ.

→ In this case velocity have two factors-

(i) Vcosθ is parallel to the magnetic field, due to it charge tends to perform translatory motion.

(ii) Vsinθ is ⊥ to the magnetic field, due to it charge tends to perform circular motion.

→ Due to both charge perform helical motion.

Time Period-

Centripetal force = Magnetic field force

$$\frac{mV_\perp^2}{r} = qV_\perp B \sin 90^\circ$$

$$\frac{mV\sin\theta}{r} = qB$$

$$r = \frac{mV\sin\theta}{qB} \quad \text{— (1)}$$

$$T = \frac{\text{Distance}}{\text{Speed}}$$

$$T = \frac{2\pi r}{V_\perp}$$

$$T = \frac{2\pi}{V\sin\theta} \times \frac{mV\sin\theta}{qB}$$

$$T = \frac{2\pi m}{qB}$$

Pitch - Distance travelled by charged particle in one complete revolution in the direction of magnetic field is called Pitch.

distance = Speed × Time

$$x = V_{\parallel} \times T$$

$$x = v\cos\theta \times \frac{2\pi m}{qB}$$

$$x = v\cos\theta \times \frac{2\pi m}{qB} \times \frac{\sin\theta}{\sin\theta}$$

$$x = \frac{2\pi m v \sin\theta}{qB} \quad \frac{\cos\theta}{\sin\theta}$$

$$x = 2\pi r \cot\theta$$

$$x = \frac{2\pi r}{\tan\theta}$$

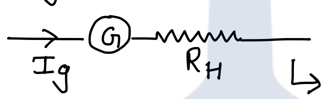
BOARD:- 2022

26. A moving charge can produce - [1 Marks]
    - A. Only electric field
    - B. Only magnetic field
    - C. Both Electric & Magnetic field
    - D. None of these

Answer - C.

27. How can a galvanometer be converted into a voltmeter? [1 Marks]

⇒ A high resistance galvanometer is called Volt meter.



↳ High Resistor series with galvanometer.

BOARD:- 2023

28. The force b/w two parallel current carrying conductor is ______.

⇒ $F = \frac{\mu_0 I_1 I_2}{2\pi d} l$

29. Ampere's Law & Solenoid.

BOARD:- 2024

30. When a charged particle moves in a uniform magnetic field in a direction perpendicular to the field, then the path of the particle will be-
    - A. parabolic
    - B. Circular
    - C. Straight line
    - D. Helical

Answer - B.

31. To convert a galvanometer into a voltmeter a resistance of ______ value is connected in series to it.

⇒ High value.

32. Derive expression of magnetic field at any point on the axis for a current carrying circular loop by Biot-Savart's Law. Draw necessary Diagram. [2+1 = 3]

33. Derive formula for the force per unit length acting on the two straight parallel current carrying conductors. Draw necessary diagram. [2+1 = 3]