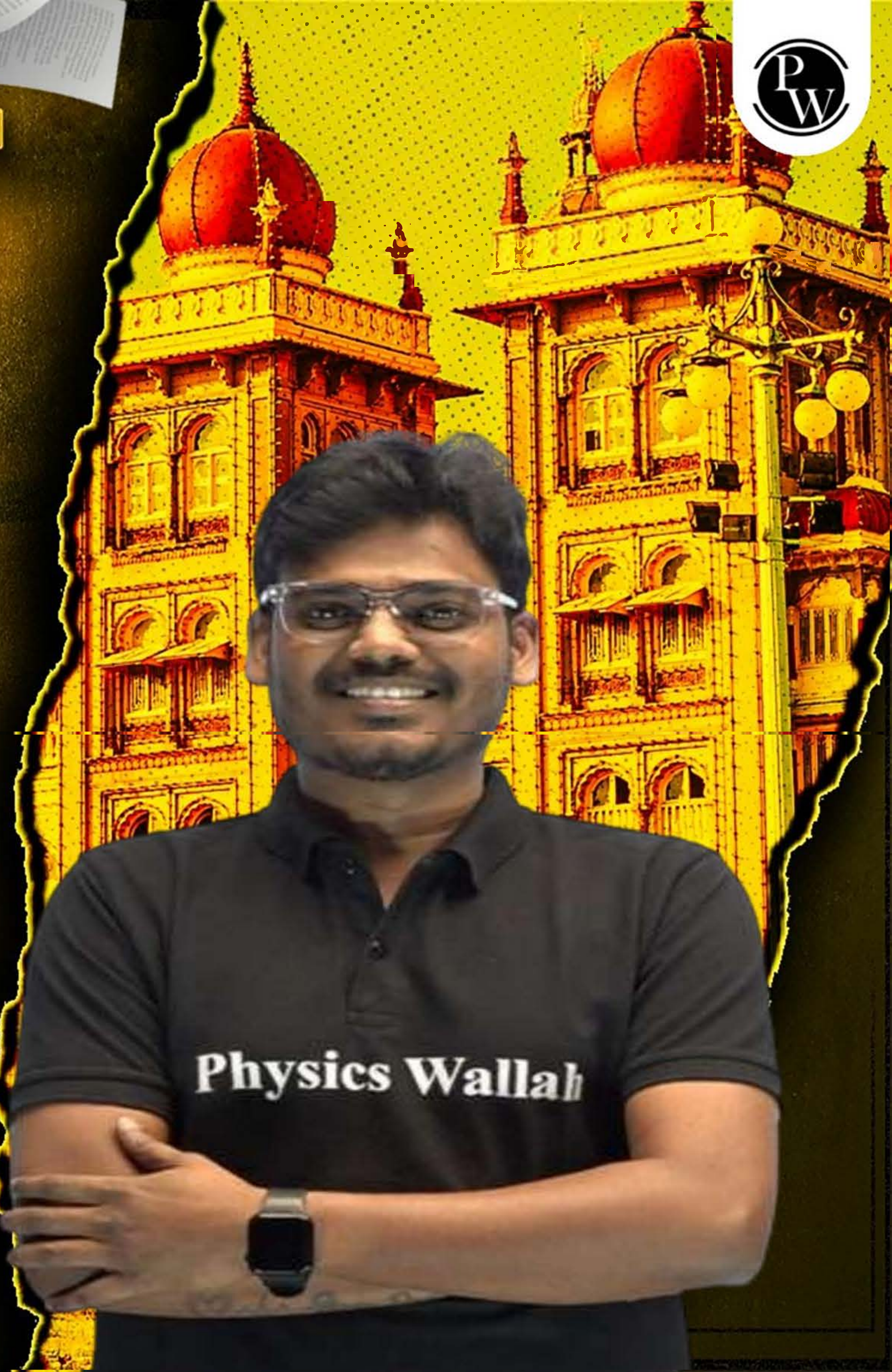
ULTIMATE KCET

CRASH COURSE 2026

PHYSICS | Lecture - 01

MOVING CHARGES AND Magnetism

By – AK SIR



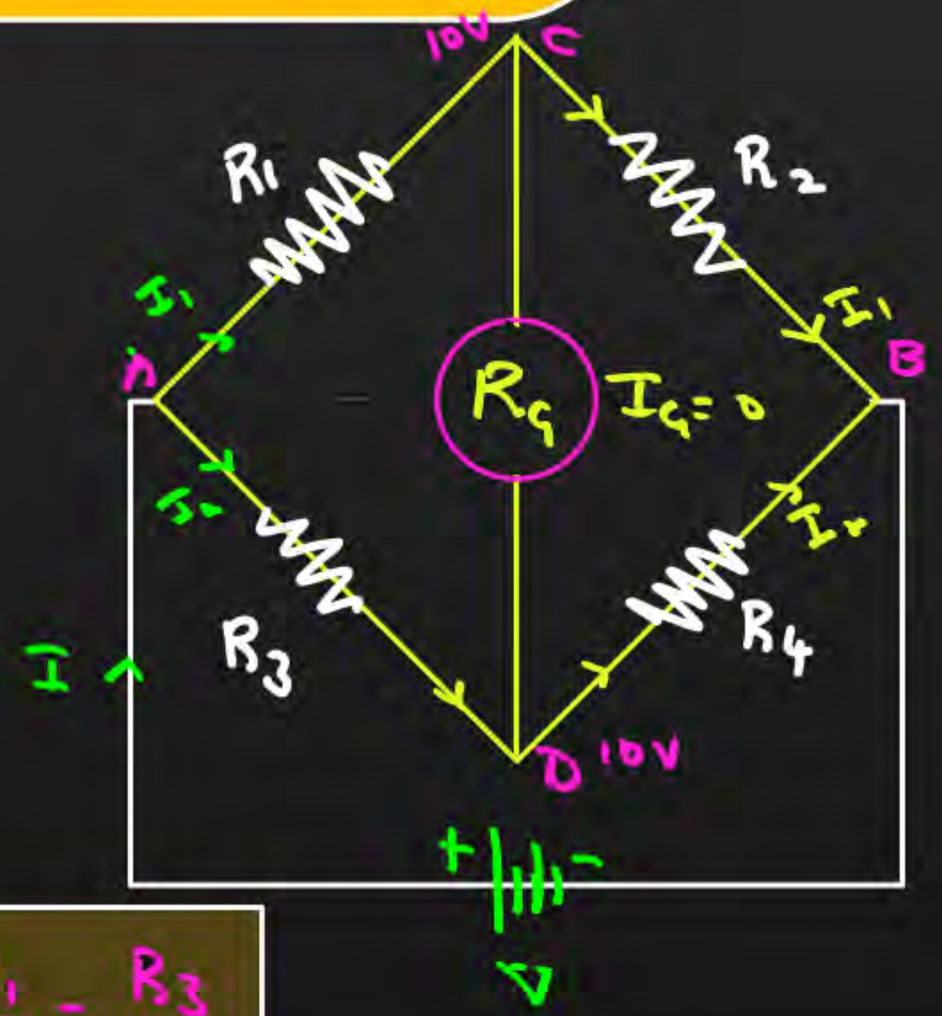
Topics *to be covered*

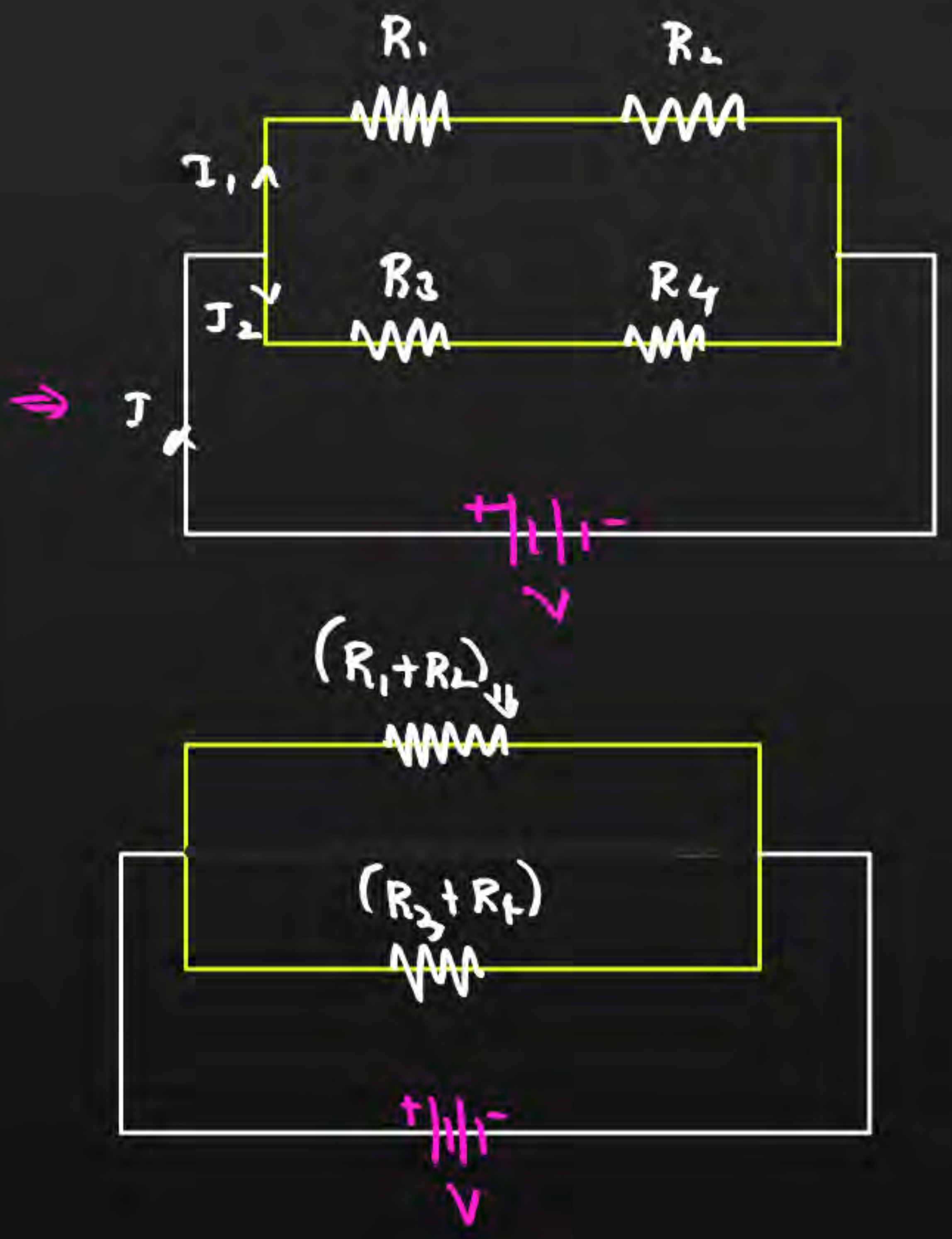
1. WHEAT STONE BRIDGE
2. MAGNETIC FIELD AND ITS SOURCE
3. BIOT-SAVARTS LAW AND ITS APPLICATIONS
4. QUESTIONS

Wheatstone's bridge

For Balanced condition

$I_g = 0$





In terms of resistance : $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

In terms of potential difference : $V_C = V_D$

$$R_T = \frac{(R_1 + R_2)(R_3 + R_4)}{R_1 + R_2 + B_3 + R_4}$$

$$I = \frac{V}{R_T}$$

Question

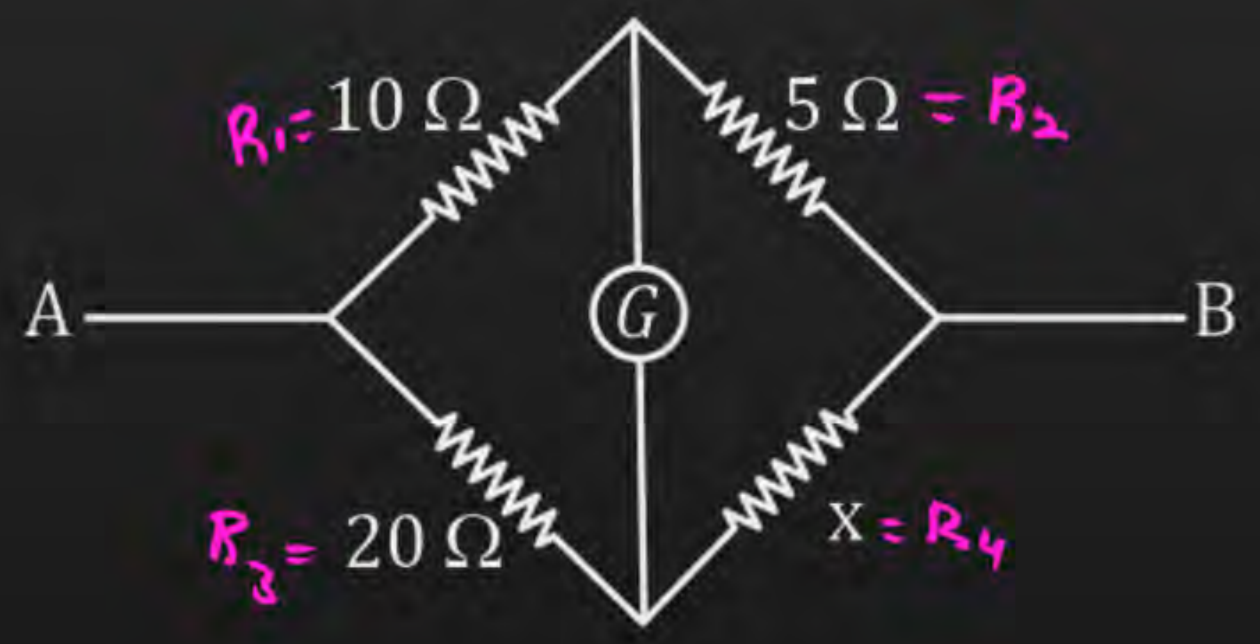
If there is no deflection in galvanometer, then value of resistance x will be-

$I_g = 0$

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$

$\frac{10}{5} = \frac{20}{x}$

$x = 10\,\Omega$



Question

If $V_C = V_D$, then value of resistance x will be-

↳ $\Delta V = 0$, $I_4 = 0$

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow \frac{3}{1} = \frac{6}{R_4}$$

$R_4 = 2$

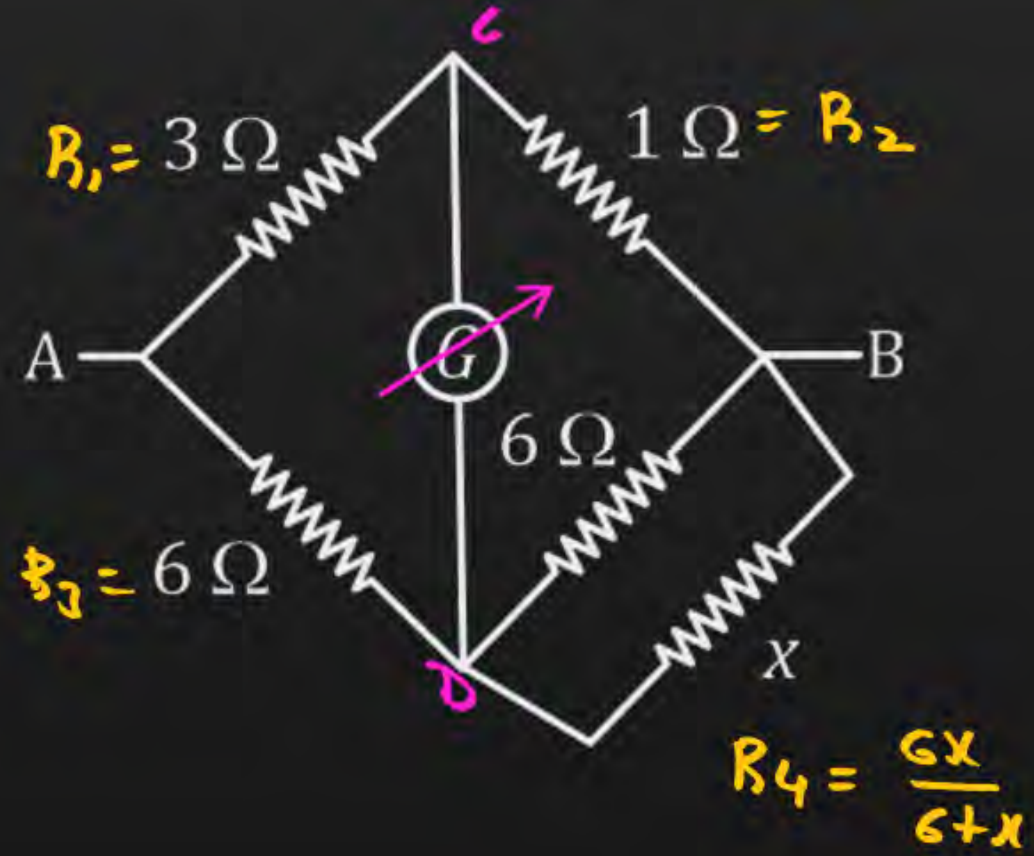
$$\frac{6x}{6+x} = 2 \Rightarrow \frac{3x}{6+x} = 1$$

$3x = 6 + x$

$3x - x = 6$

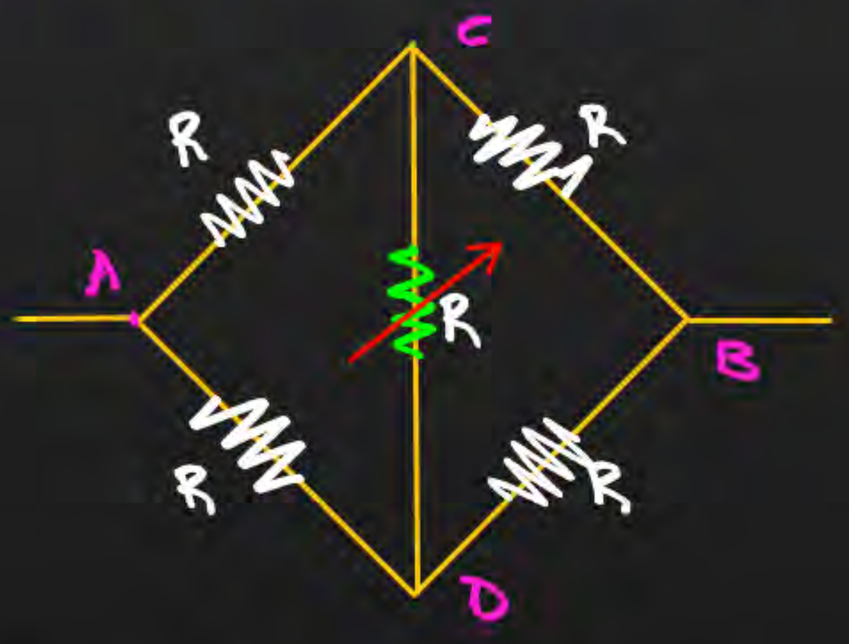
$2x = 6$

$x = 3\,\Omega$



Question

If each of the resistance of the network shown in the figure is R, the equivalent resistance between A and B is :



(A) 5 R

(B) 3 R

(C) R

(D) R / 2

$$R_T = \frac{(R+R)(R+R)}{R+R+R+R} = \frac{2R \times 2R}{4R} = R$$

$$R_T = R$$

Question

In the Wheatstone's network given, $P = 10\Omega$, $Q = 20\Omega, R = 15\Omega, S = 30\Omega$, the current passing through the battery (of negligible internal resistance) is

A 0.36 A

B zero

C 0.18 A

D 0.72 A

$$R_T = \frac{(P+R)(Q+S)}{P+Q+R+S} = \frac{(10+15)(20+30)}{10+20+15+30}$$

$$R_T = \frac{25 \times 50}{75} = \frac{50}{3}$$

$$I = \frac{V}{R_T} = \frac{6}{\frac{50}{3}} = \frac{6 \times 3}{50}$$

$$I = 0.36\,A$$

For Galvanometer, $I_g = 0$

$$\frac{P}{R} = \frac{10}{15} = \frac{2}{3}$$

$$\frac{Q}{S} = \frac{20}{30} = \frac{2}{3}$$

$$\frac{P}{R} = \frac{Q}{S}$$

MOVING CHARGES AND MAGNETISM

KCET analysis of chapter - Marks weightage

Year	Topic
2025 (4Q)	Force between two long parallel wires, Magnetic field due to centre of solenoid, Conversion of galvanometer into ammeter and Rules of magnetism, Magnetic field due to infinitely long straight wire
2024(4Q)	Moving electron, MF due to coil(2), Velocity of particle in B,
2023(4Q)	Cyclotron, Velocity of particle in B (2) and Moving coil galvanometer
2022(4Q)	MF due to coil, Moving coil galvanometer, Lorentz force and Self Induction
2021(4Q)	Stationary electron, MF due to two parallel wire, Toroid and Solenoid

KCET analysis of chapter - Marks weightage

Year	Topic
2020(4Q)	MF due to Arc, B-r Graph(2) and Cyclotron.
2019(4Q)	Cyclotron, Toroid, Galvanometer and MF due to Arc
2018(4Q)	Biot-Savarts law, Moving electron(2) and Cyclotron
2017(4Q)	MF due to straight wire, Galvanometer, MF due to loop and charged particles in MF.
2016(4Q)	MF due to Arc, Galvanometer, Motion of charge in MF and Cyclotron
2015(6Q)	MF due to Coil, Two parallel wires, Galvanometer(2), Cyclotron, Motion of charge in MF and

Magnetic Field

SOURCES OF MAGNETIC FIELD

- **Charge at rest**
  ↳ E.F only
- **Charge moving constant velocity**
  ↳ Both E.F + M.F
- **Accelerated charge**
  E.F + M.F + Radiates EMW

→ oersted expt

It is the space around moving charges or current carrying conductor where magnetic effects can be observed

Quantity - Vector.

Symbol - $\vec{B}$
- $d\vec{B}$

Unit - Tesla (T), Wb/m^2

Question

A moving electron produces

A Only electric field

B Both electric and magnetic field

C Only magnetic field

D Neither electric nor magnetic field

Question

Who concluded that moving charges or currents produces a magnetic field?

(A) J. C. Maxwell

(B) H. C. Oersted

(C) J. A. Fleming

(D) J. C. Bose

Direction → Maxwell's RHTR.

Biot-savart's Law

1. directly proportional to the strength of the electric current. $\propto I$

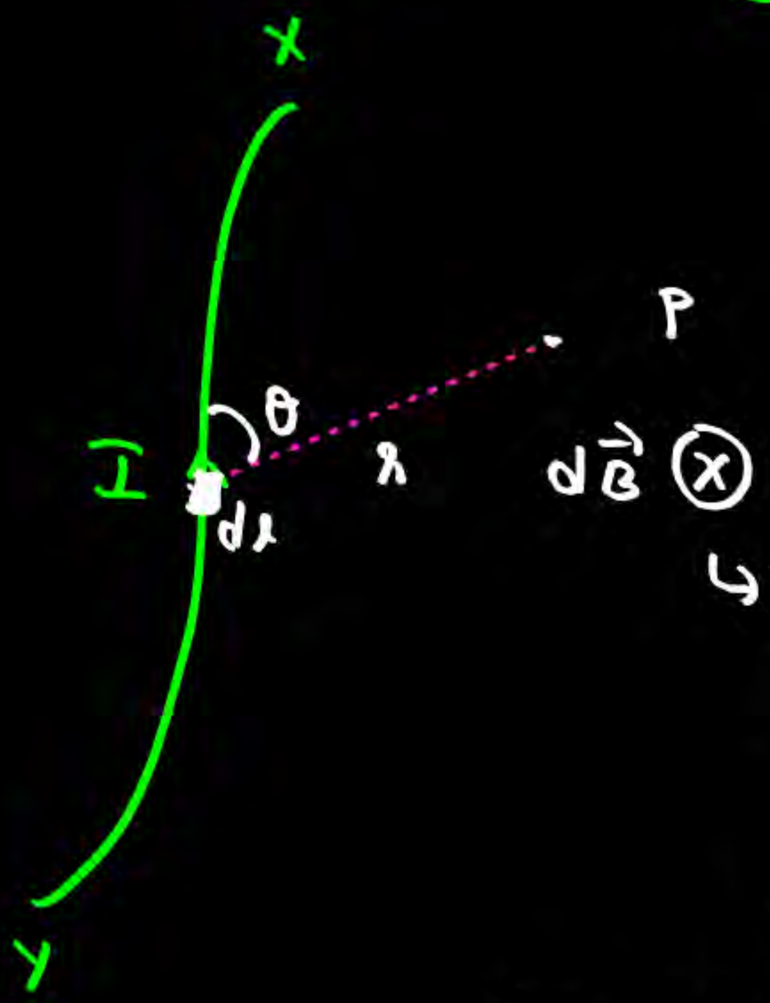
2. directly proportional to the length of the current element. $\propto dl$

3. directly proportional to the sine of the angle between the current element and the line joining the point which magnetic field is calculated . $\propto \sin\theta$

4. Inversely proportional to square of the distance between the current element and the point at which the magnetic field is calculated. $\propto \frac{1}{r^2}$

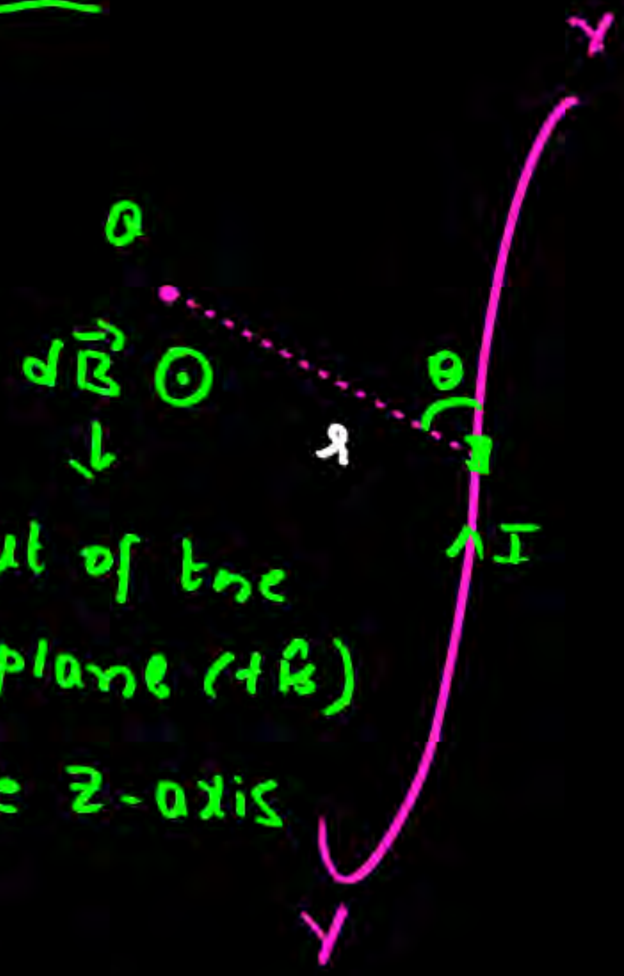
Maxwell's RHTR

$I.\vec{dl}$
↓
vector



↳ Into the plane $(-\hat{k})$

i.e −z-axis



↓ Out of the plane $(+\hat{k})$

i.e z-axis

$dB \propto I.dl$

$dB \propto \sin\theta$

$dB \propto \frac{1}{r^2}$

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

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

Biot-savart's Law

Consider a conductor XY carrying a current *I*. The conductor be divided into small parts each of length *dl*. Let P be a point at the distance (*r*) from the current element.

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

$$\frac{\mu_0}{4\pi} = 10^{-7}\ H/m$$

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\,r}{r^2\,r}\sin\theta = \frac{\mu_0}{4\pi}\frac{I}{r^3}(dl\,r\sin\theta)$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi r^3}(d\vec{l}\times\vec{r})$$

→ Direction.

dl - Elemental current , direction along the direction of current

$dl \times r$ - screw rule

Question

The magnetic field $\overrightarrow{dB}$ due to a small current element $\overrightarrow{dl}$ at a distance and element carrying current i is

(A) $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i^2 \left(\frac{\overrightarrow{dl} \times \vec{r}}{r} \right)$

(B) $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^3} \right)$

(C) $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^2} \right)$

(D) $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i^2 \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^2} \right)$

Question

Which of the following statements is not true regarding Biot-Savart's law,

A The magnetic field is proportional to the length of the current element, $\propto l$

B The magnetic field is proportional to the current through the current element $\propto I$

C The magnetic field is inversely proportional to the distance of the point $\propto \frac{1}{r}$

$\hookrightarrow \frac{1}{r^2}$ $\hookrightarrow \frac{1}{r^3}$

D The magnetic field is proportional to the sine of the angle between the current direction and the line joining the current element and the point

$\propto \sin\theta$

Question

The value of permeability of free space is

$\frac{\mu_0}{4\pi} = 10^{-7}$ H/m

$\mu_0 = 4\pi \times 10^{-7}$ H/m

A) $4\pi \times 10^{-7}$ H/m

B) 9×10^{9} Nm^2/C^2

C) 8.854×10^{-12} F/m

D) 3×10^{8} m/s

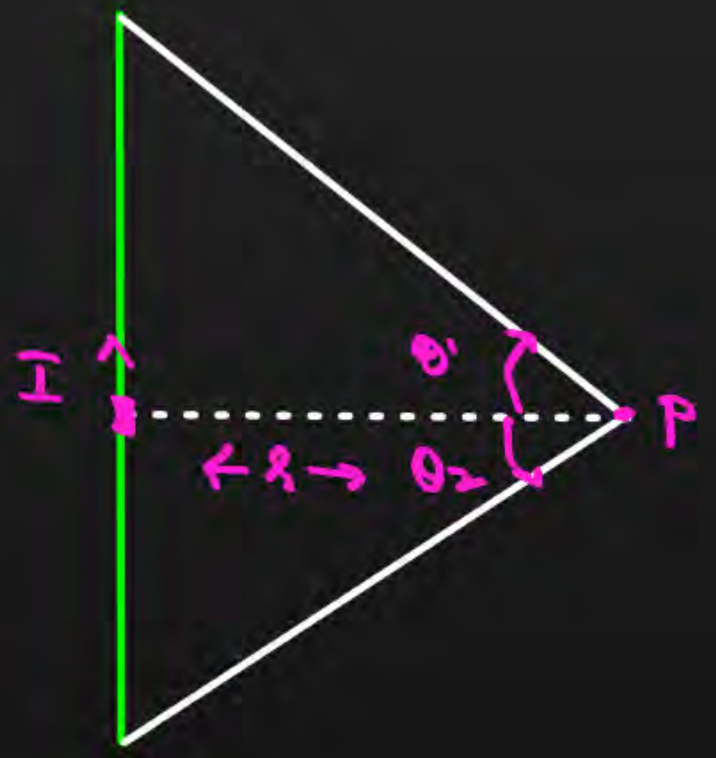
Magnetic field due to current carrying wire

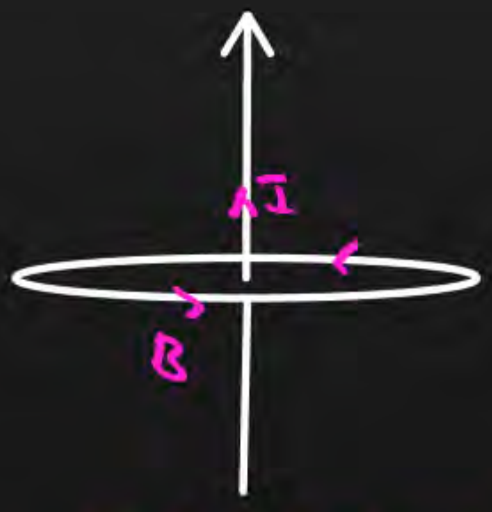
1. Magnetic field due to finite straight current carrying conductor/wire

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

$$B = \int dB$$

$$B = \frac{\mu_0}{4\pi}\frac{I}{r}\left(\sin\theta_1 + \sin\theta_2\right)$$





Magnetic field due to current carrying wire

1. a. Magnetic field due to infinite straight current carrying conductor/wire

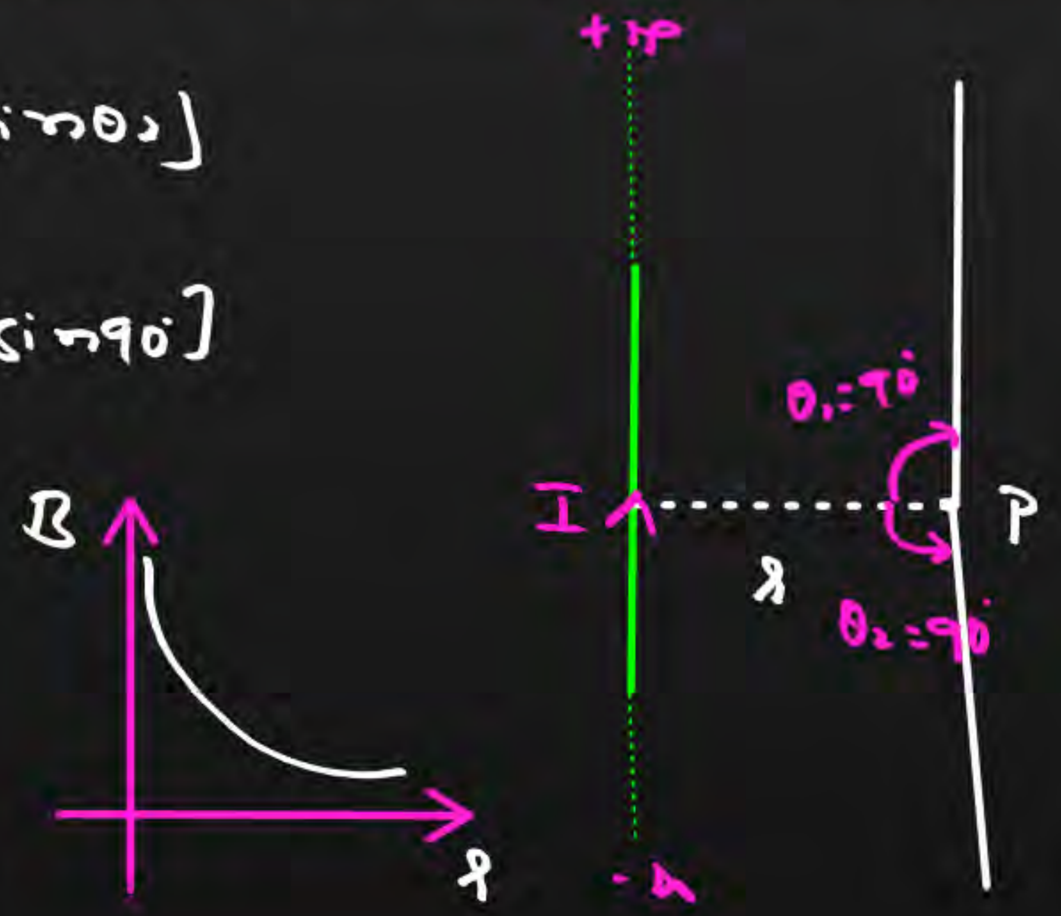
$$B = \frac{\mu_0 I}{4\pi r}[\sin\theta_1 + \sin\theta_2]$$

$$B = \frac{\mu_0 I}{4\pi r}[\sin 90^\circ + \sin 90^\circ]$$

$$B = \frac{\mu_0 I}{4\pi r}[1+1]$$

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

$B \propto \frac{1}{r}$

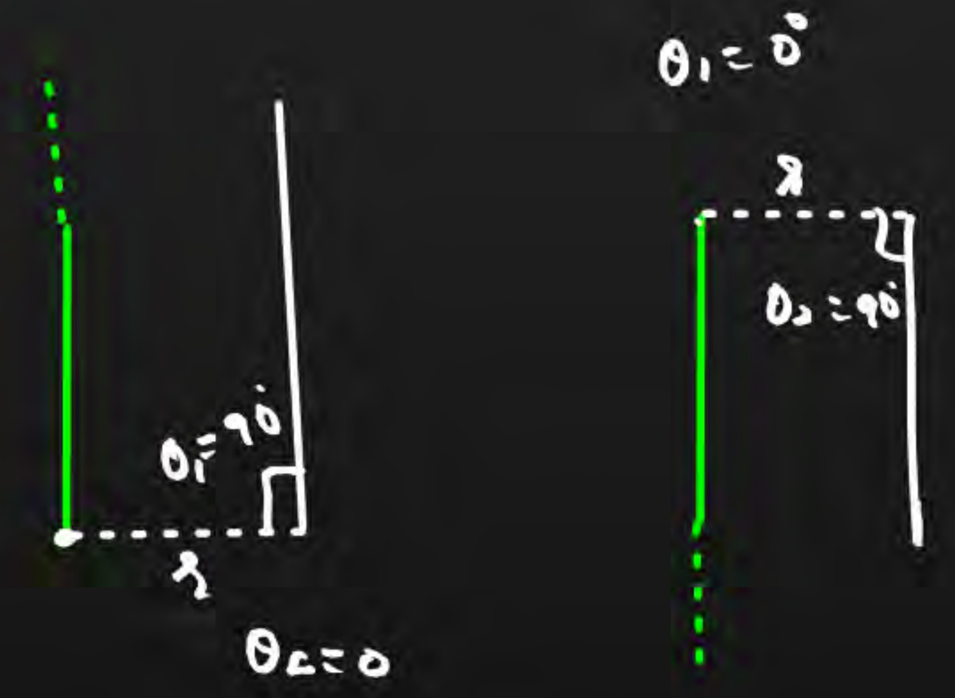


Magnetic field due to current carrying wire

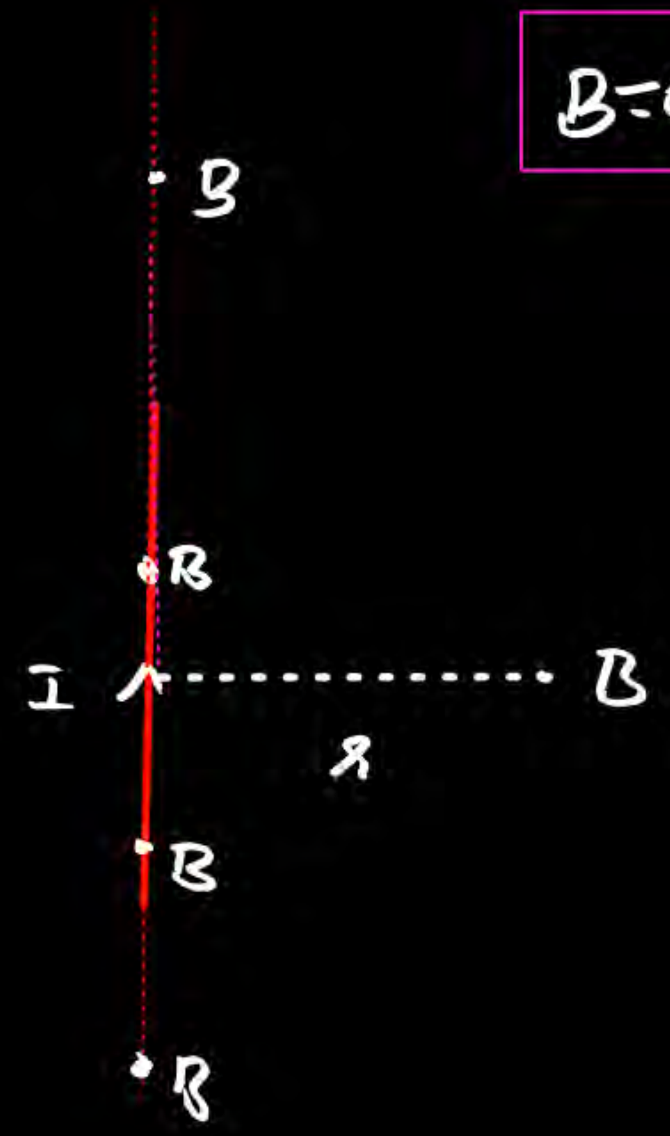
1. b. Magnetic field due to semi-finite straight current carrying conductor/wire

$$B = \frac{\mu_0}{4\pi}\frac{I}{r}\left[\sin\theta_1 + \sin\theta_2\right]$$

$$\boxed{B = \frac{\mu_0 I}{4\pi r}}$$



$B = 0$ $\quad \theta = 0°$



Question

A long straight wire carrying a current induced magnetic induction at any place that is

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

$B \propto \frac{1}{r}$

(A) Proportional to the distance from the wire $\propto r$

(B) Independent of distance.

(C) Inversely proportional to the distance from the wire $\propto \frac{1}{r}$

(D) Inversely proportional to the square of the distance from the wire $\propto \frac{1}{r^2}$

Magnetic field due to current carrying wire

2. Magnetic field at the centre due to current carrying Arc

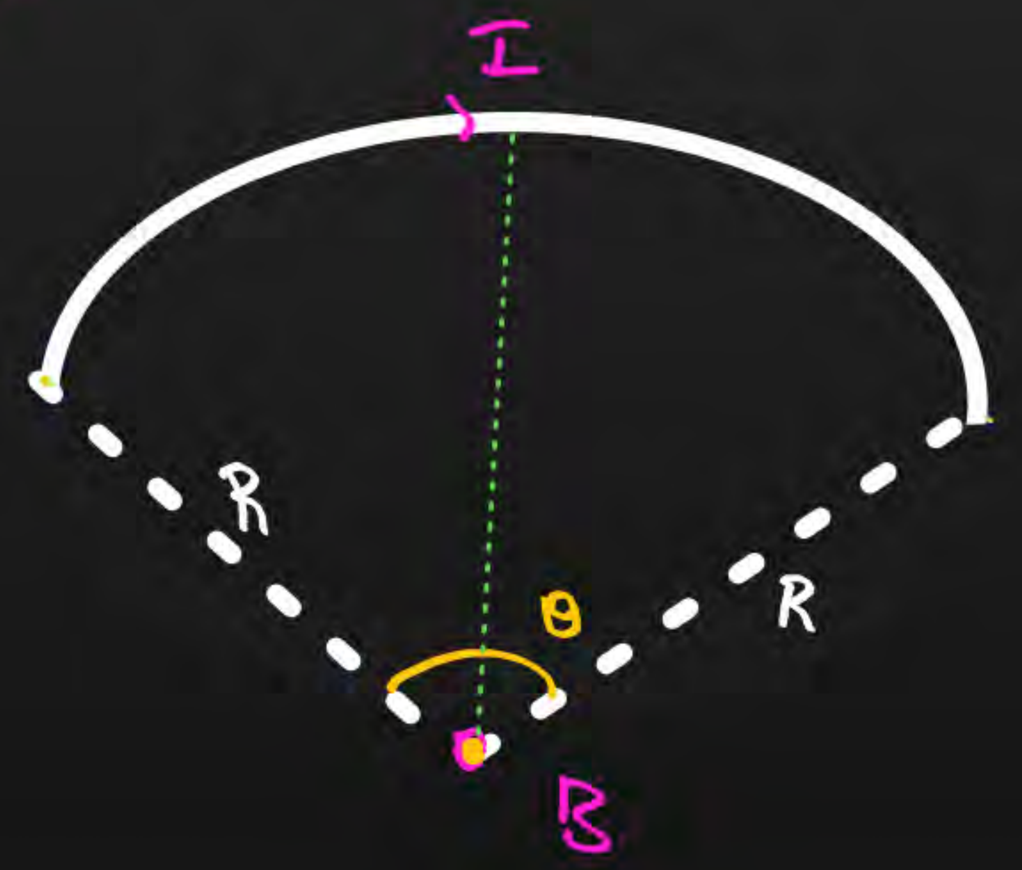
$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$$

$N = 1$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$$

θ → Radian

$\theta^\circ \rightarrow \frac{\pi}{180} \times \theta^\circ$ rad.



Magnetic field due to current carrying wire

2. (a) Magnetic field at the centre due to current carrying semi-circular Loop/Ring

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right) \qquad \theta : 180^\circ = \pi$$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\pi}{2\pi}\right)$$

$$\boxed{B = \frac{\mu_0 I}{4R}}$$

Magnetic field due to current carrying wire

2. (b) Magnetic field at the centre due to current carrying quadrant

$\theta = 90^\circ = \frac{\pi}{2}$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\pi}{2 \times 2\pi}\right)$$

$$B = \frac{\mu_0 I}{8R}$$

Magnetic field due to current carrying wire

2. (c) Magnetic field at the centre due to current carrying circle

$\theta = 360° = 2\pi$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$$

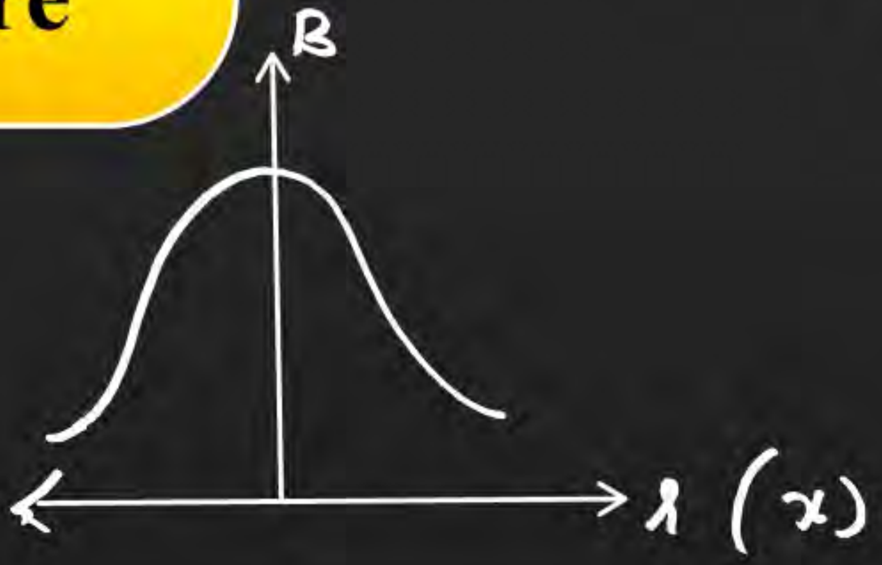
$$B = \frac{\mu_0 I}{2R}\left(\frac{2\pi}{2\pi}\right)$$

$$B = \frac{\mu_0 I}{2R} \quad N = 1$$

$$B = \frac{\mu_0 N I}{2R} \quad N > 1$$

Magnetic field due to current carrying wire

3. Magnetic field due to current carrying loop on the axis.



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

At centre $x = 0$

$$B = \frac{\mu_0 N I R^2}{2(R^2 + 0^2)^{3/2}} = \frac{\mu_0 N I}{2R}$$

Question

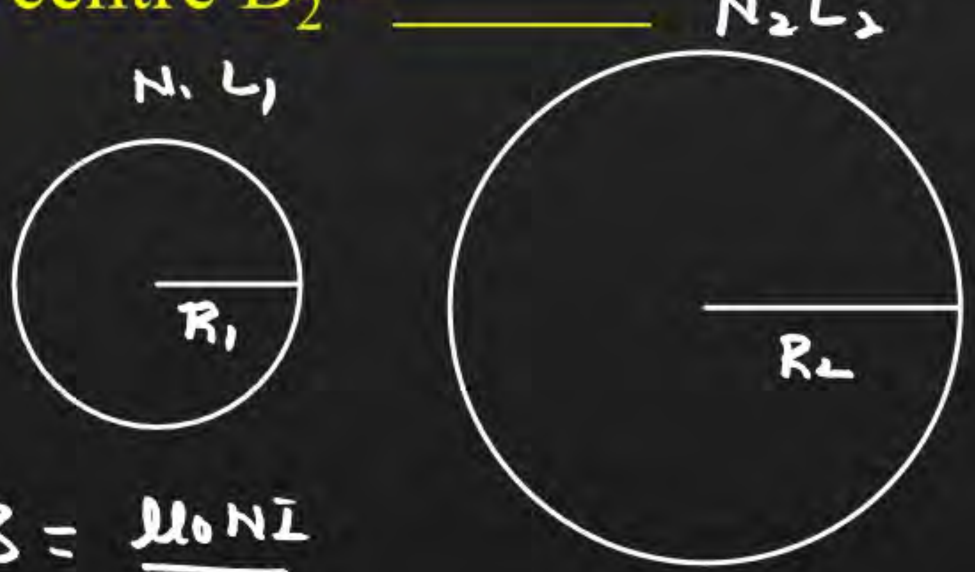
A coil having 9 turns carrying a current produces magnetic field B_1 at the centre. Now the coil is rewounded into 3 turns carrying same current. Then the magnetic field at the centre B_2 = ______

(A) $\frac{B_1}{9}$

(B) $9\,B_1$

(C) $3\,B_1$

(D) $\frac{B_1}{3}$



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

$$B_1 = \frac{\mu_0 \times 9 I}{2R_1}$$

$$B_1 = 9\frac{\mu_0 I}{2R_1}$$

$$B_2 = \frac{\mu_0 \times 3 I}{2R_2}$$

$$B_2 = 3\frac{\mu_0 I}{2R_2}$$

$$N_1 L_1 = N_2 L_2$$

$$9 \times 2\pi R_1 = 3 \times 2\pi R_2$$

$$3R_1 = R_2$$

$$\frac{B_2}{B_1} = \frac{3\mu_0 I}{2R_2} \times \frac{2R_1}{9\mu_0 I} = \frac{R_1}{3R_2} = \frac{R_1}{3 \times 3R_1} = \frac{1}{9}$$

$$B_2 = \frac{B_1}{9}$$

Question

The magnetic field at the centre of a circular coil of radius R carrying current I is 64 times the magnetic field at a distance x on its axis from the centre of the coil. Then the value of x is

(A) $\frac{R}{4}\sqrt{15}$

(B) $R\sqrt{3}$

(C) $\frac{R}{4}$

(D) $R\sqrt{15}$

$B_c = 64 B_a$

$\frac{\mu_0 I}{2R} = 64 \times \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$

$(R^2+x^2)^{3/2} = 64R^3 = 4^3 R^3$

x'e powers $\frac{2}{3}$

$(R^2+x^2)^{\frac{3}{2}\times\frac{2}{3}} = 4^{3\times\frac{2}{3}} R^{3\times\frac{2}{3}}$

$R^2+x^2 = 4^2 R^2$

$(R^2+x^2) = (4R)^2 = 16R^2$

$16R^2 - R^2 = x^2$

$15R^2 = x^2$

$x = \sqrt{15} R$

Question

A circular coil of wire of radius r has n turns and carries a current I. The magnetic induction B at a point on the axis of the coil at a distance $\sqrt{3}r$ from its centre is

(A) $\frac{\mu_0 nI}{8r}$

(B) $\frac{\mu_0 nI}{16r}$

(C) $\frac{\mu_0 nI}{4r}$

(D) $\frac{\mu_0 nI}{32r}$

$x = \sqrt{3}r$

$4^{1/2} = \sqrt{4} = 2$

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

$$B = \frac{\mu_0 n I r^2}{2\left[r^2+(\sqrt{3}r)^2\right]^{3/2}}$$

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

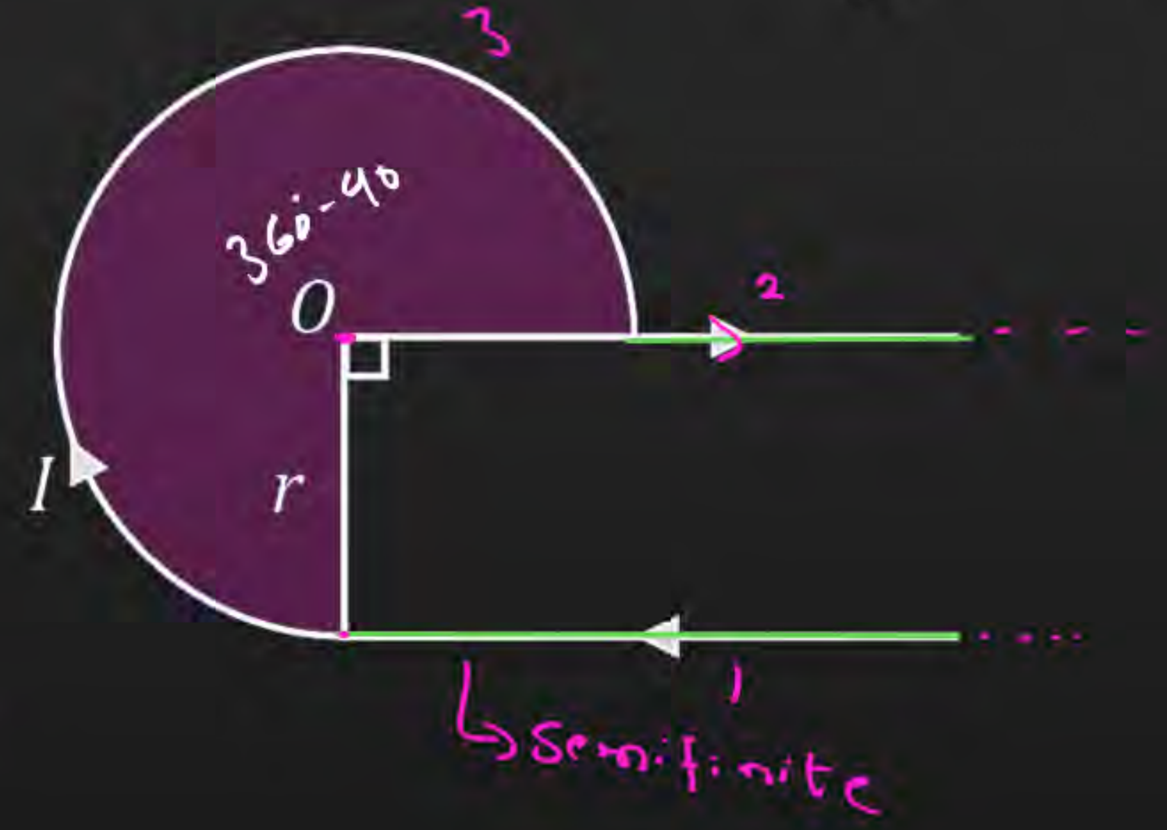
$$B = \frac{\mu_0 n I r^2}{2(4r^2)^{3/2}} = \frac{\mu_0 n I r^2}{2\left[4^{3/2} \times r^{2\times\frac{3}{2}}\right]}$$

$$B = \frac{\mu_0 n I r^2}{2\left[(2)^3 r^3\right]} = \frac{\mu_0 n I}{2\times 8\times r}$$

$$B = \frac{\mu_0 n I}{16r}$$

Question

In the given figure, the magnetic field at O.



A) $\frac{3}{4}\frac{\mu_0 I}{r}+\frac{\mu_0 I}{4\pi r}$

B) $\frac{3}{10}\frac{\mu_0 I}{r}-\frac{\mu_0 I}{4\pi r}$

C) $\frac{3}{8}\frac{\mu_0 I}{r}+\frac{\mu_0 I}{4\pi r}$

D) $\frac{3}{8}\frac{\mu_0 I}{r}-\frac{\mu_0 I}{4\pi r}$

$270° = \frac{\pi}{180} \times 270 = \frac{3\pi}{2}$

$B_1 = \frac{\mu_0 I}{4\pi r}$ $\quad B_2 = 0$

$B_3 = \frac{\mu_0 I}{2r}\left(\frac{\theta}{2\pi}\right)$

$B_3 = \frac{\mu_0 I}{2r}\left(\frac{3\pi}{2\times 2\pi}\right) = \frac{3\mu_0 I}{8r}$

$B_0 = B_1 + B_2 + B_3$

$= \frac{\mu_0 I}{4\pi r} + 0 + \frac{3\mu_0 I}{8r}$

$B_0 = \frac{\mu_0 I}{4\pi r} + \frac{3\mu_0 I}{8r}$

Question

The magnetic fields at the centre O in the given figure is

(A) $\frac{7}{14}\frac{\mu_0 I}{R}$

(B) $\frac{5}{12}\frac{\mu_0 I}{R}$

(C) $\frac{3}{10}\frac{\mu_0 I}{R}$

(D) $\frac{\mu_0 I}{12R}$

$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$

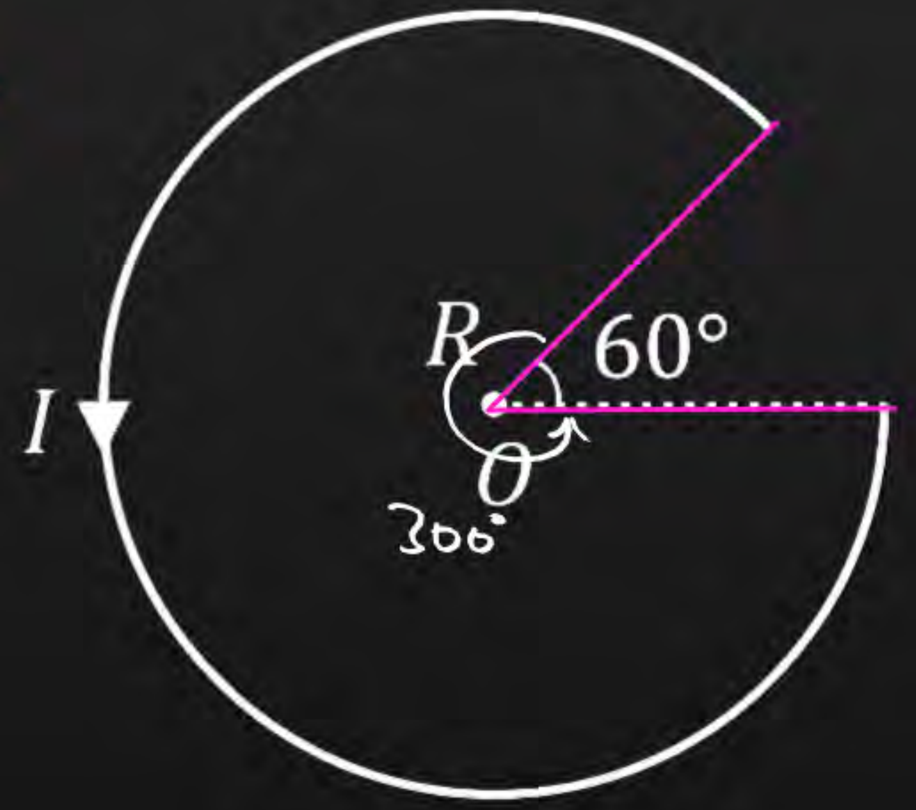
$\theta = 300^\circ$

$\theta = 300 \times \frac{\pi}{180}$

$\theta = \frac{5\pi}{3}$

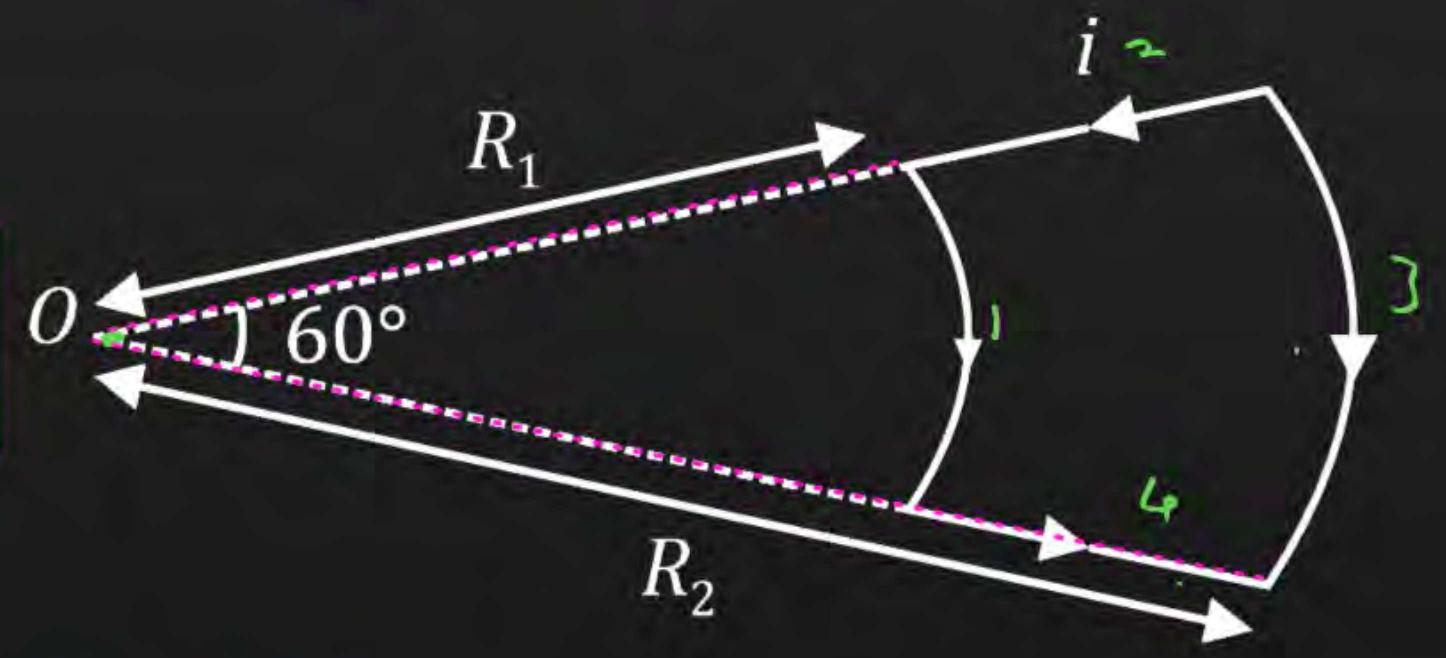
$B = \frac{\mu_0 I}{2R}\left(\frac{5\pi}{3 \times 2\pi}\right)$

$B = \frac{5\mu_0 I}{12R}$



Question

A conducting wire carrying current is arranged as shown in the figure. The magnetic field at O is



A $\frac{\mu_0 i}{12}\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

B $\frac{\mu_0 i}{12}\left[\frac{1}{R_1}+\frac{1}{R_2}\right]$

C $\frac{\mu_0 i}{6}\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

D $\frac{\mu_0 i}{6}\left[\frac{1}{R_1}+\frac{1}{R_2}\right]$

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$$

$$60^\circ = \frac{\pi}{180} \times 60 = \frac{\pi}{3}$$

$$B_1 = \frac{\mu_0 I}{2R_1}\left(\frac{\pi}{3 \times 2\pi}\right)$$

$$B_1 = \frac{\mu_0 I}{12 R_1} \qquad B_3 = \frac{\mu_0 I}{12 R_2}$$

$$B_2 = 0 \qquad B_4 = 0$$

$$B_0 = B_1 + B_2 + B_3 + B_4 = \frac{\mu_0 I}{12 R_1} + \frac{\mu_0 I}{12 R_2}$$

$$B_0 = \frac{\mu_0 I}{12}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Question

Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. If 3*A* and 4*A* are the currents flowing through the two coils respectively. The magnetic induction (in Wb m^{-2}) at the centre of the coils will be

A 5×10^{-5}

B 12×10^{-5}

C 7×10^{-5}

D 10^{-5}

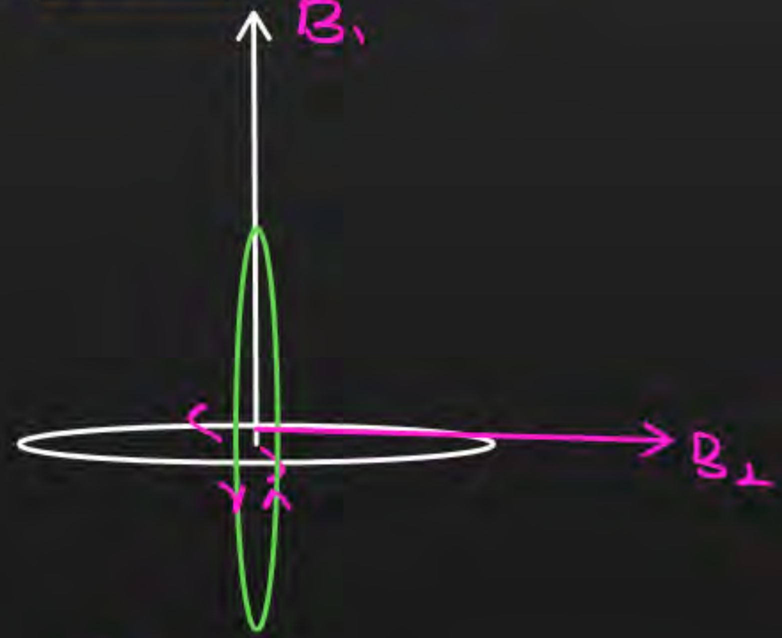
$$B = \frac{\mu_0 I}{2R}$$

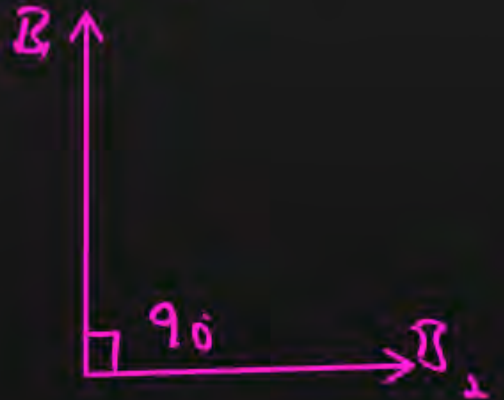
$$B_1 = \frac{\mu_0 \times 3}{2R}$$

$$B_2 = \frac{\mu_0 \times 4}{2R}$$

$$B = \frac{5 \times 4\pi \times 10^{-7}}{2 \times 2\pi \times 10^{-2}}$$

$$B = 5 \times 10^{-5}\ T$$





$$R_{max} = A + B, \quad \theta = 0^\circ$$

$$R_{min} = A - B, \quad \theta = 180^\circ$$

$$R = \sqrt{A^2 + B^2}, \quad \theta = 90^\circ$$

$$B = \sqrt{B_1^2 + B_2^2}$$

$$B = \sqrt{\left(\frac{3\mu_0}{2R}\right)^2 + \left(\frac{4\mu_0}{2R}\right)^2}$$

$$B = \frac{\mu_0}{2R}\sqrt{9+16} = \frac{5\mu_0}{2R}$$

Question

In the slope shown, the magnetic induction at the point O is

$B_1 = 0$, $B_3 = 0$, $B_5 = 0$, $B_6 = 0$

(A) zero

(B) $\dfrac{\mu_0 I}{8}\left(\dfrac{R_1 - R_2}{R_1 R_2}\right)$

(C) $\dfrac{\mu_0 I}{8}\left(\dfrac{R_1 + R_2}{R_1 R_2}\right)$

(D) $\dfrac{\mu_0 I}{8}\left(\dfrac{R_1 R_2}{R_1 + R_2}\right)$

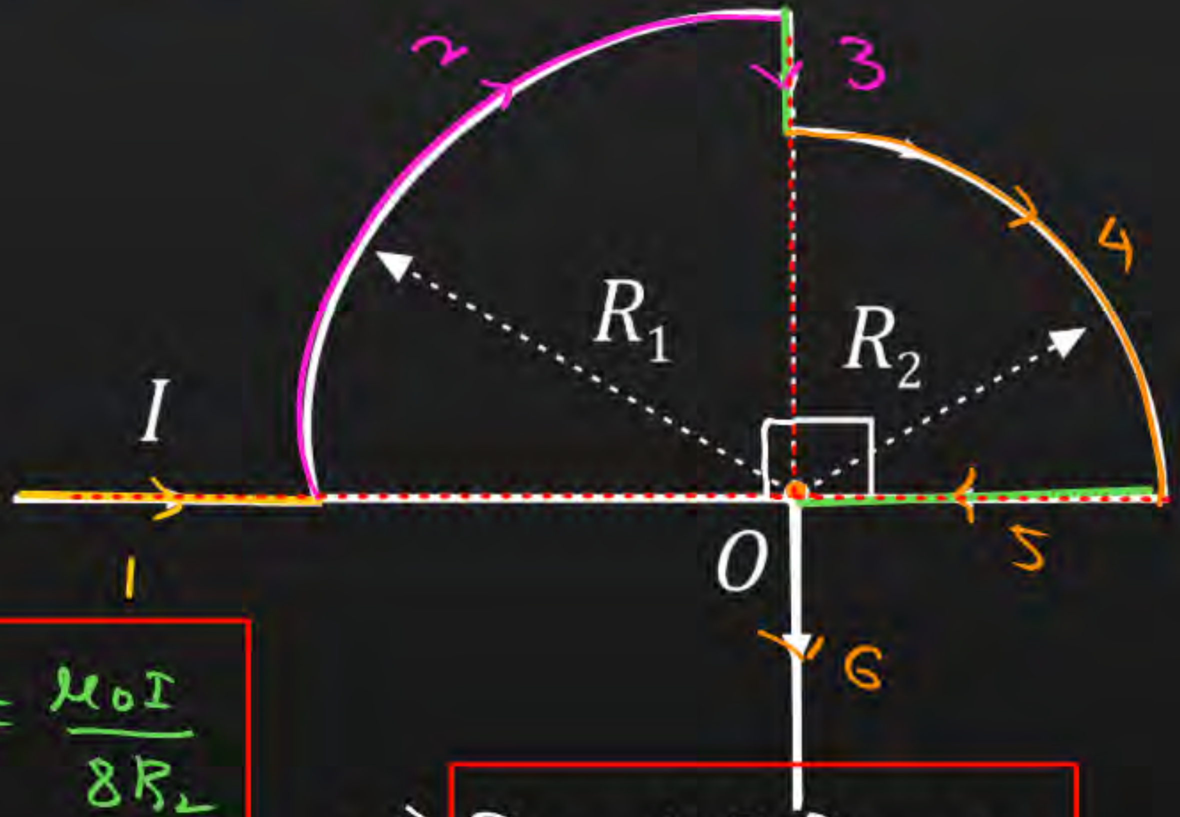
$B = \dfrac{\mu_0 I}{2R}\left(\dfrac{\theta}{2\pi}\right)$

$B_2 \Rightarrow \theta = 90^\circ = \dfrac{\pi}{2}$

$B_2 = \dfrac{\mu_0 I}{2R_1}\left(\dfrac{\pi}{2 \times 2\pi}\right)$

$B_2 = \dfrac{\mu_0 I}{8R_1}$

$B_4 = \dfrac{\mu_0 I}{8R_2}$



$B_0 = \dfrac{\mu_0 I}{8R_1} + \dfrac{\mu_0 I}{8R_2} = \dfrac{\mu_0 I}{8}\left[\dfrac{1}{R_1} + \dfrac{1}{R_2}\right]$

$B_0 = \dfrac{\mu_0 I}{8}\left[\dfrac{R_1 + R_2}{R_1 R_2}\right]$

Question

Current I is flowing in conductor shaped as shown in the figure. The radius of the curved part is r and the length of straight portion is very large. The value of the magnetic field at the centre O will be

(A) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}+1\right)$

(B) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}-1\right)$

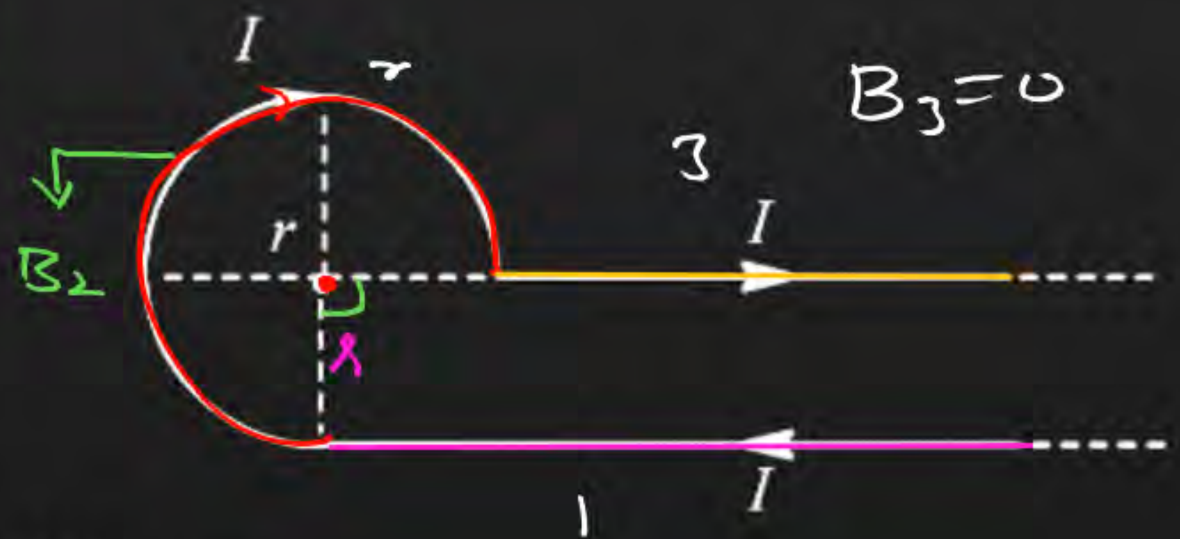
(C) $\frac{\mu_0 I}{4\pi r}\left(\frac{\pi}{2}+1\right)$

(D) $\frac{\mu_0 I}{4\pi r}\left(\frac{\pi}{2}-1\right)$

$B_2 = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$, $270^\circ = \frac{3\pi}{2}$

$B_2 = \frac{\mu_0 I}{2r}\left(\frac{3\pi}{2\times 2\pi}\right)$

$B_2 = \frac{3\mu_0 I}{8r}$



$B_0 = \frac{\mu_0 I}{4\pi r} + \frac{3\mu_0 I}{8r}\times\frac{\pi}{\pi}$

$B_1 = \frac{\mu_0 I}{4\pi r}$

$B_0 = \frac{\mu_0 I}{4\pi r}\left[1+\frac{3\pi}{2}\right]$

$B_0 = \frac{\mu_0 I}{4\pi r}\left[1+\frac{3\pi}{2}\right]$

Question

The magnetic field at the centre of a circular current carrying conductor of radius r is B_c. The magnetic field on its axis at a distance r from the centre is B_a. The value of $B_c : B_a$ will be

(A) $1 : \sqrt{2}$

(B) $1 : 2\sqrt{2}$

(C) $2\sqrt{2} : 1$

(D) $\sqrt{2} : 1$

$B_c = \frac{\mu_0 I}{2r}$

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

$x = r$ (R)

$B_a = \frac{\mu_0 I r^2}{2(r^2+r^2)^{3/2}}$

$B_a = \frac{\mu_0 I r^2}{2(2r^2)^{3/2}}$

$B_a = \frac{\mu_0 I r^2}{2\left[2^{3/2} \times r^{2 \times \frac{3}{2}}\right]} = \frac{\mu_0 I}{2\sqrt{8}\, r}$

$\frac{B_c}{B_a} = \frac{\mu_0 I}{2r} \times \frac{2\sqrt{8}\, r}{\mu_0 I} = \sqrt{8} = \sqrt{4 \times 2} = 2\sqrt{2}$

$\frac{B_c}{B_a} = \frac{2\sqrt{2}}{1}$

Question

$B' = n^2 B$

A circular coil carrying a certain current produces a magnetic field B_0 at its centre. The coil is now rewound so as to have 3 turns and the same current is passed through it. The new magnetic field at the centre is

(A) $B_0/9$

(B) $9B_0$

(C) $B_0/3$

(D) $3B_0$

$B_0 = \frac{\mu_0 I}{2R_1}$

$N_1 L_1 = N_2 L_2$

$1 \times 2\pi R_1 = 3 \times 2\pi R_2$

$R_1 = 3R_2$

$B' = \frac{\mu_0 I N}{2R_2}$

$B' = \frac{3\mu_0 I}{2R_2}$

$\frac{B'}{B_0} = \frac{3\mu_0 I}{2R_2} \times \frac{2R_1}{\mu_0 I} = \frac{3R_1}{R_2} = \frac{3 \times 3R_2}{R_2}$

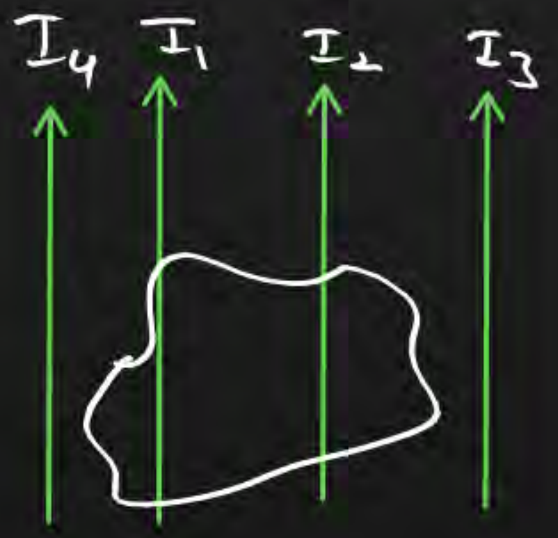
$B' = 9B_0$

Ampere's Circuital Law

⇒ Alternate method to find (B)

The line integral of the magnetic field (magnetic flux density) around any closed path in free space is equal to μ_0 times the net current threading through the area enclosed by the path.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$



$I_T = I_1 + I_2$

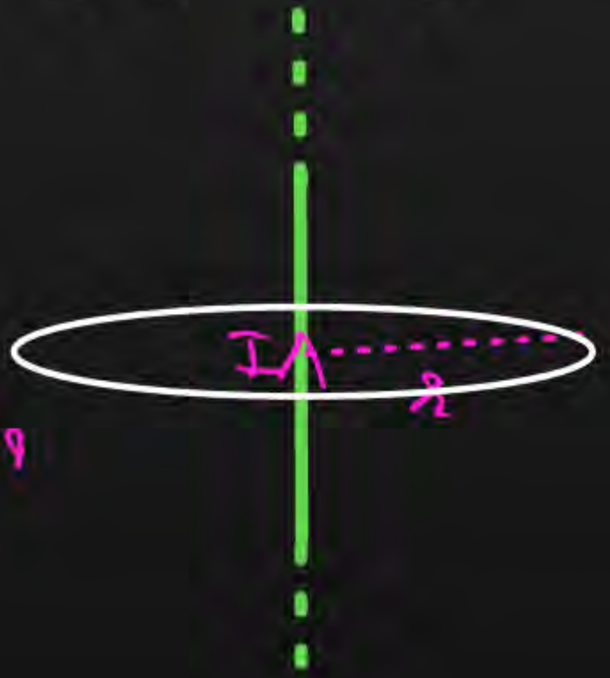
Ampere's Circuital Law

1. Magnetic Field of long straight thin wire :

Let **B** be the magnetic field at a point **P** distance **r** from a long straight wire carrying a current **I,** Let us draw a circle of radius **r** around the wire. By symmetry, **B** is tangent to the circle everywhere.

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

$$B \propto \frac{1}{r}$$



Ampere's Circuital Law

→ Like spherical shell case.

2. Magnetic Field due to infinitely long hollow cylindrical wire carrying current on its surface.

(i) For external point

$r > R$ $\quad E = \frac{Kq}{r^2}$ $\quad B = \frac{\mu_0 I}{2\pi r}$

$r = R$ $\quad E = \frac{Kq}{R^2}$ $\quad B = \frac{\mu_0 I}{2\pi R}$

$r < R$ $\quad E = 0$ $\quad B = 0$

$\quad q = 0$ $\quad I = 0$

Ampere's Circuital Law

→ Like non-conducting sphere case

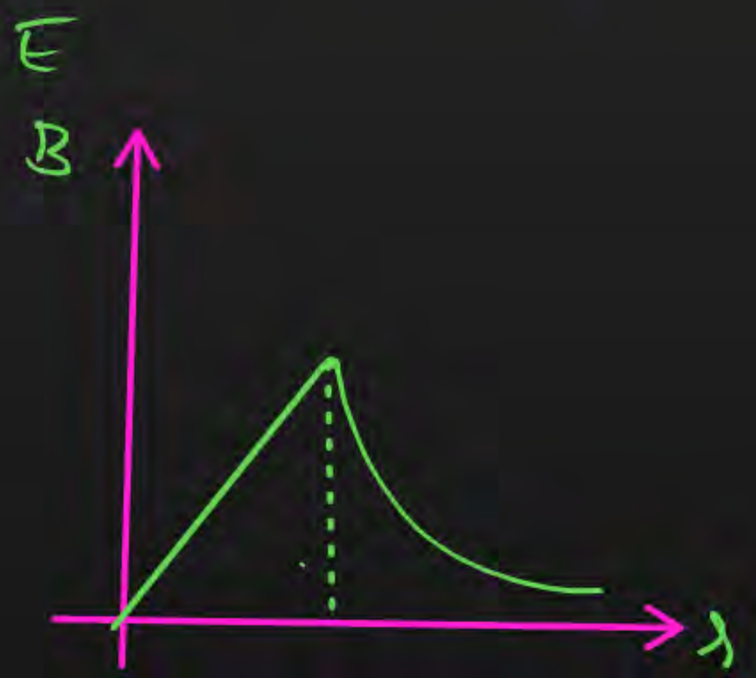
3. Magnetic Field due to infinitely long solid cylindrical wire carrying current 'I' distributed uniformly across its cross-section.

(i) For external point

$r > R$ $\quad E = \frac{Kq}{r^2}$ $\quad B = \frac{\mu_0 I}{2\pi r}$.

$r = R$ $\quad E = \frac{Kq}{R^2}$ $\quad B = \frac{\mu_0 I}{2\pi R}$

$r < R$ $\quad E = \frac{Kqr}{R^3}$ $\quad B = \frac{\mu_0 I r}{2\pi R^2}$



Ampere's Circuital Law

$L = \mu_0 n^2 A l$

$L = \mu_0 n^2 V$

4. Magnetic Field of a long straight solenoid: A coil of many circular turns of insulated copper wire wrapped closely in the shape of the cylinder is called solenoid.

→ centre

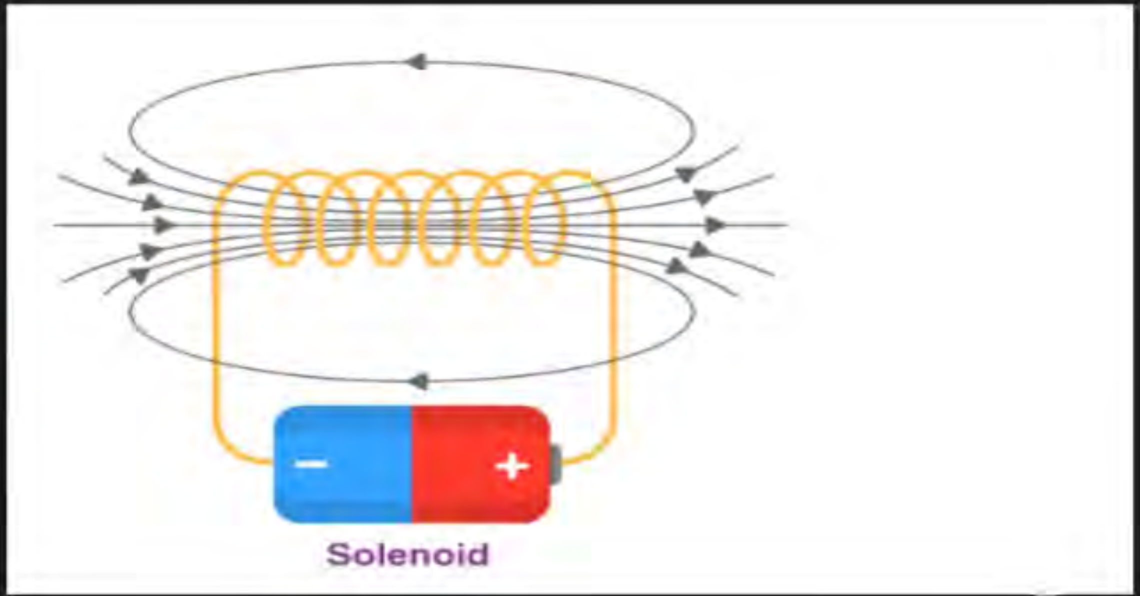
$$B = \mu_0 n I$$

$n = \frac{N}{L}$

↳ Independent of radius or Diameter.

↳ At end

$$B_{end} = \frac{B}{2} = \frac{\mu_0 n I}{2}$$



Question

A solenoid is 1 m long and 4 cm in diameter. It has five layers of windings of 1000 turns each and carries a current of 7 A. The magnetic field at the centre of the solenoid is

(A) 4.396×10^{-3} T

(B) 49.6 T

(C) 43.96×10^{-2} T

(D) 4.396×10^{-2} T

$B = \mu_0 n I \rightarrow$ 1- Layer.

$n = \frac{N}{L} = \frac{1000}{1} = 10^3$

$B = 4\pi \times 10^{-7} \times 10^3 \times 7$

$B = 87.92 \times 10^{-4}$

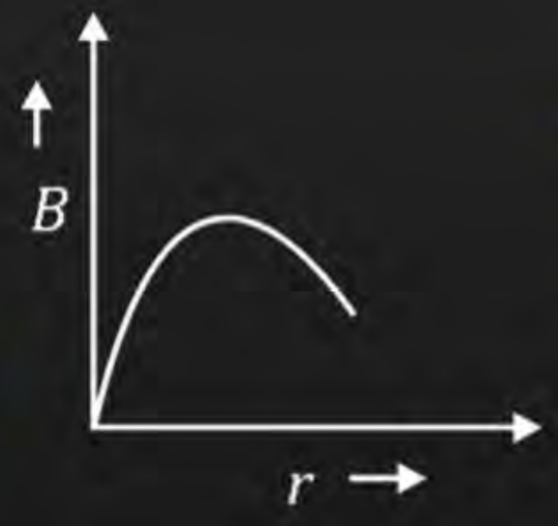
$B_T = 5B$ — 5- Layers

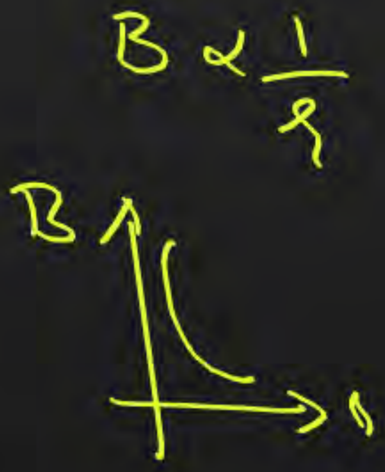
$B_T = 439.6 \times 10^{-4} = 4.396 \times 10^{-2}$ T

Question

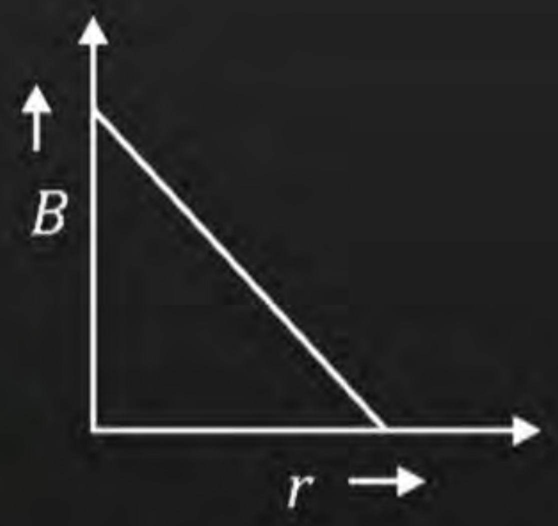
Which of the following graphs represent the variation of magnetic field B with perpendicular distance r from an infinitely long, straight conductor carrying current?

(A)

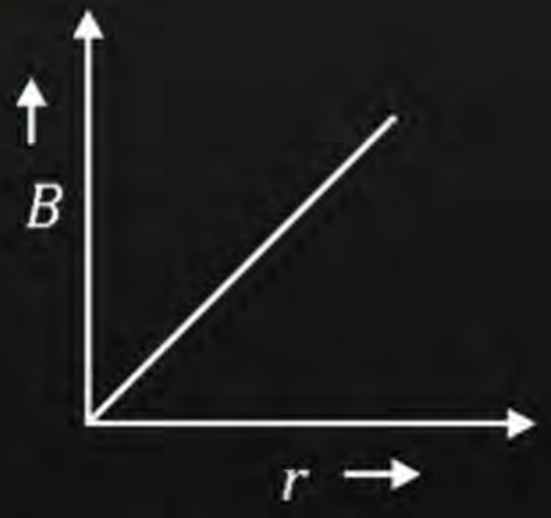




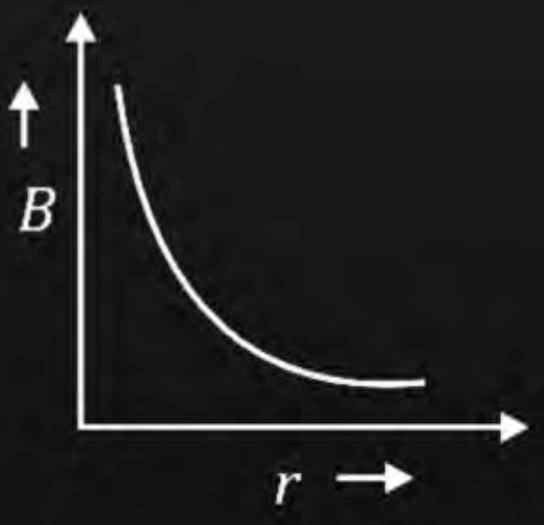
(B)



(C)



(D)



Question

The magnetic field at the centre of a current carrying loop of radius 0.1 m is $5\sqrt{5}$ times that at a point along its axis. The distance of this point from the centre of the loop is

(A) 0.1m

(B) 0.2m

(C) 0.05m

(D) 0.25m

$B_c = 5\sqrt{5}\, B_a$

$\frac{\mu_0 I}{2R} = 5\sqrt{5}\, \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$

$(R^2+x^2)^{3/2} = 5\sqrt{5} \cdot R^3$

$(R^2+x^2)^{3/2} = 5 \times 5^{1/2} R^3$

$(R^2+x^2)^{3/2} = \sqrt{125}\, R^3$

$\div 3 \quad (R^2+x^2)^{1/2} = (125)^{1/6}\, R^{1/2}$

Solve $\Rightarrow$

$R^2 + x^2 =$

Question

A solenoid has length 0.4 cm, radius 1 cm and 400 turns of wire. If a current of 5A is passed through this solenoid, what is the magnetic field inside the solenoid?

(A) 6.28×10^{-4} T

(B) 6.28×10^{-1} T

(C) 6.28×10^{-7} T

(D) 6.28×10^{-6} T

$B = \mu_0 n I$

$n = \frac{N}{L} = \frac{400}{0.4 \times 10^{-2}} = \frac{400}{4 \times 10^{-3}}$

$n = 10^2 \times 10^3 = 10^5$

$B = 4\pi \times 10^{-7} \times 10^5 \times 5 = 62.8 \times 10^{-2}$

$B = 6.28 \times 10^{-1}$ T

Question

Magnetic field at a distance r from an infinitely long straight conductor carrying a steady current varies as

(A) $1/\sqrt{r}$

(B) $1/r^2$

(C) $1/r$

(D) $1/r^3$

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

$$B \propto \frac{1}{r}$$

Question

Magnetic field at the centre of a circle coil of radius R due to i flowing through it is B. The magnetic field at a point along the axis at distance R from the centre is

(A) $B/2$

(B) $B/4$

(C) $B/\sqrt{8}$

(D) $\sqrt{8}B$

Question

Hollow

A direct current I flows along the length of an infinitely long straight thin walled pipe, then the magnetic field is

(A) uniform throughout the pipe but not zero ✗

(B) zero only along the axis of the pipe ✗ $r = R$

(C) zero at any point inside the pipe ✓ $r < R$, $B = 0$

(D) maximum at the centre and minimum at the edge ✗

Question

A solenoid 1.5m long and 0.4 cm in diameter possesses 10 turns per cm length. A current of 5 A falls through it. The magnetic field at the axis inside the solenoid is

(A) $2\pi \times 10^{-3}$T

(B) $2\pi \times 10^{-5}$T

(C) $4\pi \times 10^{-2}$T

(D) $4\pi \times 10^{-3}$T

$n = \frac{N}{l}$

$B = \mu_0 n I$

$n = \frac{N}{L} = \frac{10}{10^{-2}}$

$n = 10^3$

$B = 4\pi \times 10^{-7} \times 10^3 \times 5$

$B = 20\pi \times 10^{-4}$

$B = 2\pi \times 10^{-3}$ T

Question

A tightly wound 100 turns coil of radius 10 cm carries a current of 7A. The magnitude of the magnetic field at the centre of the coil is: (Take permeability of free space as $4\pi \times 10^{-7}$ SI units) :

(A) 4.4T

(B) 4.4 mT

(C) 44T

(D) 44 mT

$$B_c = \frac{\mu_0 I N}{2R}$$

$$B_c = \frac{4\pi \times 10^{-7} \times 7 \times 100}{2 \times 10 \times 10^{-2}}$$

$$B_c = 439.6 \times 10^{-5}$$

$$B_c = 4.396 \times 10^{-3}\ T$$

$$B_c = 4.39\ mT$$

Question

A long solenoid of radius 1 mm has 100 turns per mm. If 1 A current flows in the solenoid, the magnetic field strength at the centre of the solenoid is:

(A) 6.28×10^{-4}T

(B) 6.28×10^{-2}T

(C) 12.56×10^{-2}T

(D) 12.56×10^{-4}T

$n = \frac{N}{L} = \frac{100}{10^{-3}} = 10^5$

$B = \mu_0 n I$

$B = 4\pi \times 10^{-7} \times 10^5 \times 1$

$B = 12.56 \times 10^{-2}$ T

Question

Given below are two statements:

Statement I: Biot-Savart's law gives us the expression for the magnetic field strength of an infinitesimal current element (Idl) of a current-carrying conductor only.

Statement II: Biot-Savart's law is analogous to Coulomb's inverse square law of charge q, with the former being related to the field produced by a scalar source, (Idl) while the latter being produced by a vector source, q.

(A) Statement I is incorrect but Statement II is correct.

(B) Both Statement I and Statement II are correct.

(C) Both Statement I and Statement II are incorrect.

(D) Statement I is correct but Statement II is incorrect.

Question

From Ampere's circuital law, for a long straight wire of circular cross-section carrying a steady-current, the variation of the magnetic field inside and outside the region of the wire is:

A A linearly decreasing function of distance upto the boundary of the wire and then a linearly increasing one for the outside region.

B Uniform and remains constant for both regions.

C A linearly increasing function of distance upto the boundary of the wire and then a linearly decreasing one for the outside region.

D A linearly increasing function of distance r upto the boundary of the wire and then decreasing one with 1/r dependence for the outside region.

Question

$\to 10^3$

A closely packed coil having 1000 turns has an average radius of 62.8 cm. If the current carried by the wire of the coil is 1 A, the value of the magnetic field produced at the centre of the coil will be nearly: (permeability of free space = $4\pi \times 10^{-7}$ H/m):

(A) 10^{-1}T

(B) 10^{-2}T

(C) 10^{2}T

(D) 10^{-3}T

$$B_c = \frac{\mu_0 N I}{2R}$$

$$B_c = \frac{4\pi \times 10^{-7} \times 10^{3} \times 1}{2 \times 62.8 \times 10^{-2}}$$

$$B_c = 0.1 \times 10^{-2}$$

$$B_c = 1 \times 10^{-3}\,T$$

Question

The shape of the magnetic field lines due to an infinite long, straight current carrying conductor is:

(A) a straight line

(B) circular

(C) elliptical

(D) a plane

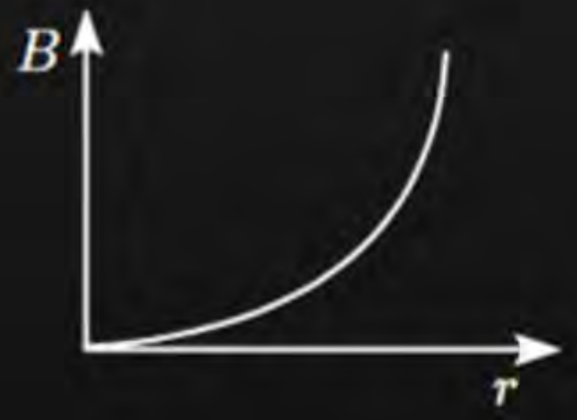
Question

A thick current-carrying cable of radius 'R' carries current 'I' uniformly distributed across its cross-section. The variation of magnetic field $B(r)$ due to the cable with the distance 'r' from the axis of the cable is represented by:

(A)

(B)

(C)

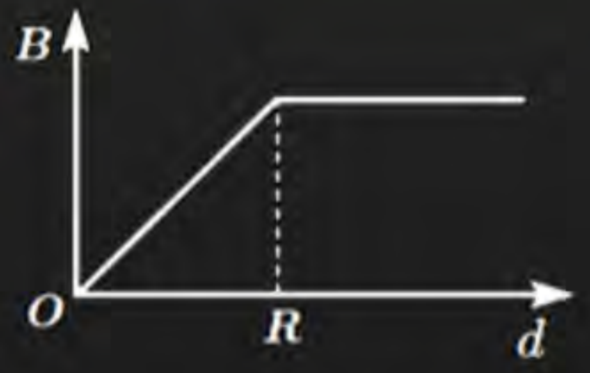


(D)

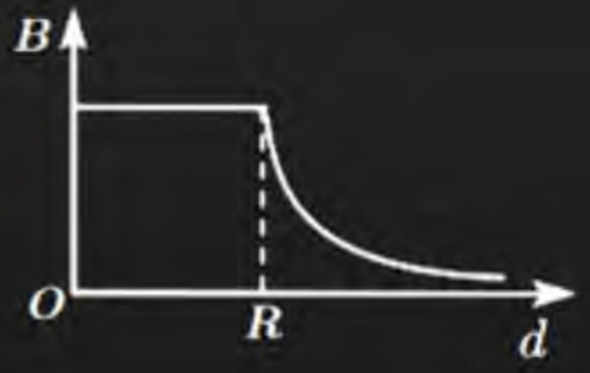
Question

A cylindrical conductor of radius R is carrying a constant current. The plot of the magnitude of the magnetic field B with the distance d from the centre of the conductor is correctly represented by the figure:

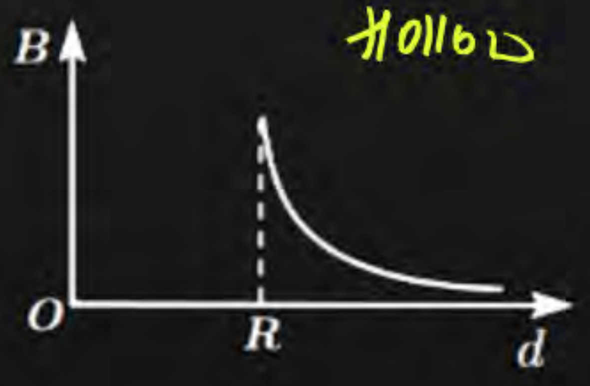
A



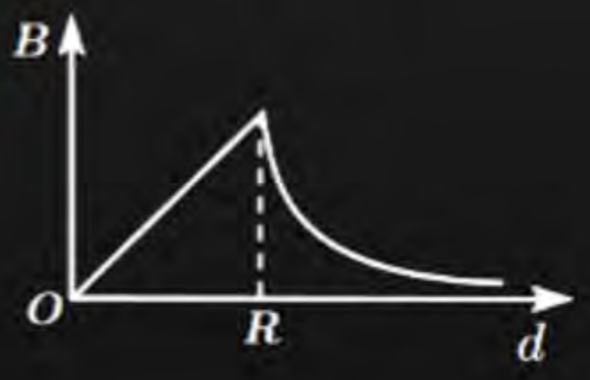
B



C



D



Thank

You