(PHYSICS) **Moving Charge Magnetism**

DPP – 2

CLASS – 12th

TOPIC – Ampere's Circuital Law and Applications

Q.1 A long straight solid conductor of radius 5 cm carries a current of 2 A, which is uniformly distributed over its circular cross-section. Find the magnetic field induction at a distance of 3 cm from the axis of the conductor.

Q.2 A straight wire carries a current of 3 A. Calculate the magnitude of the magnetic field at a point 15 cm away from the wire. Draw a diagram to show the direction of the magnetic field

Q.3 shows a right angled isosceles triangle PQR having its base equal to a. A current of I ampere is passing downwards along a thin straight wire cutting the plane of the paper normally as shown at Q. Likewise a similar wire carries an equal current passing normally upwards at R. Find the magnitude and direction of the magnetic induction B at P. Assume the wires to be infinitely long

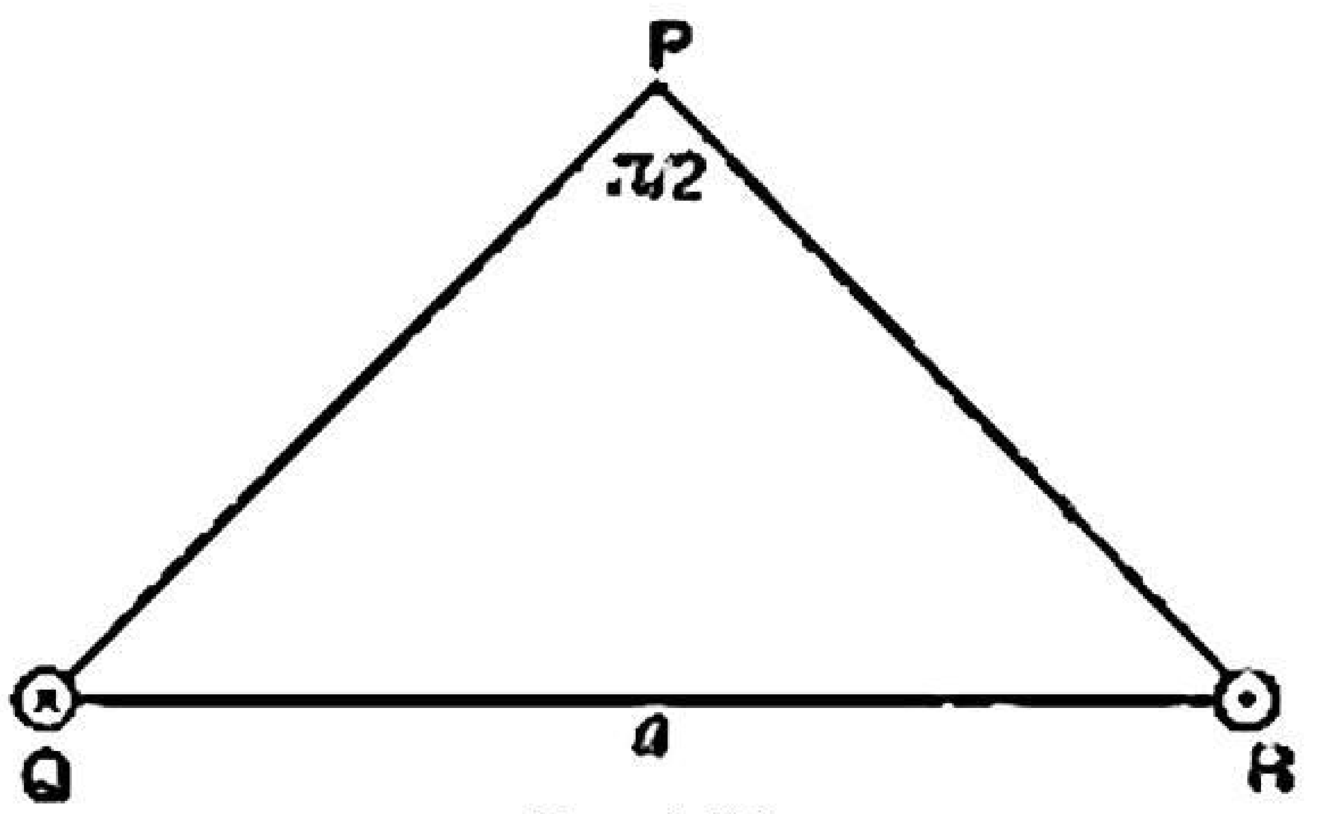

Fig. 1.32

Q.4 A 0.5 m long solenoid has 500 turns and has a flux density of 2 * 52 * 10 ^ - 3 * T at its centre. Find the current in the solenoid. Given, mu_{0} = 4pi * 10 ^ - 7 * H * m ^ - 1

Q.5 A solenoid is 2.0 m long and 3.0 cm in diameter. It has 5 layers of winding of 1,000 turns each and carries a current of 5.0 A. What is the magnetic field at its centre ? Use the standard value of μ.

Q.6 Write an expression for the magnetic field produced by an infinitely long straight wire carrying a current I, at a short perpendicular distance a from itself.

Q.7 Whar Kind of magnetic field is produced by an infinitely long current carrying conductor?

Q.8 What kind of magnetic filed is produced sue to straight solenoid?

Q.9 . How will the magnetic field intensity at the centre of a circular coil carrying current change, if the current through the coil is doubled and the radius of the coil is halved?

Q.10 Two identical circular wires P and Q, each of radius r and carrying currents I and 2 I respectively are lying in parallel planes, such that they have a common axis as shown in Fig. 1.42

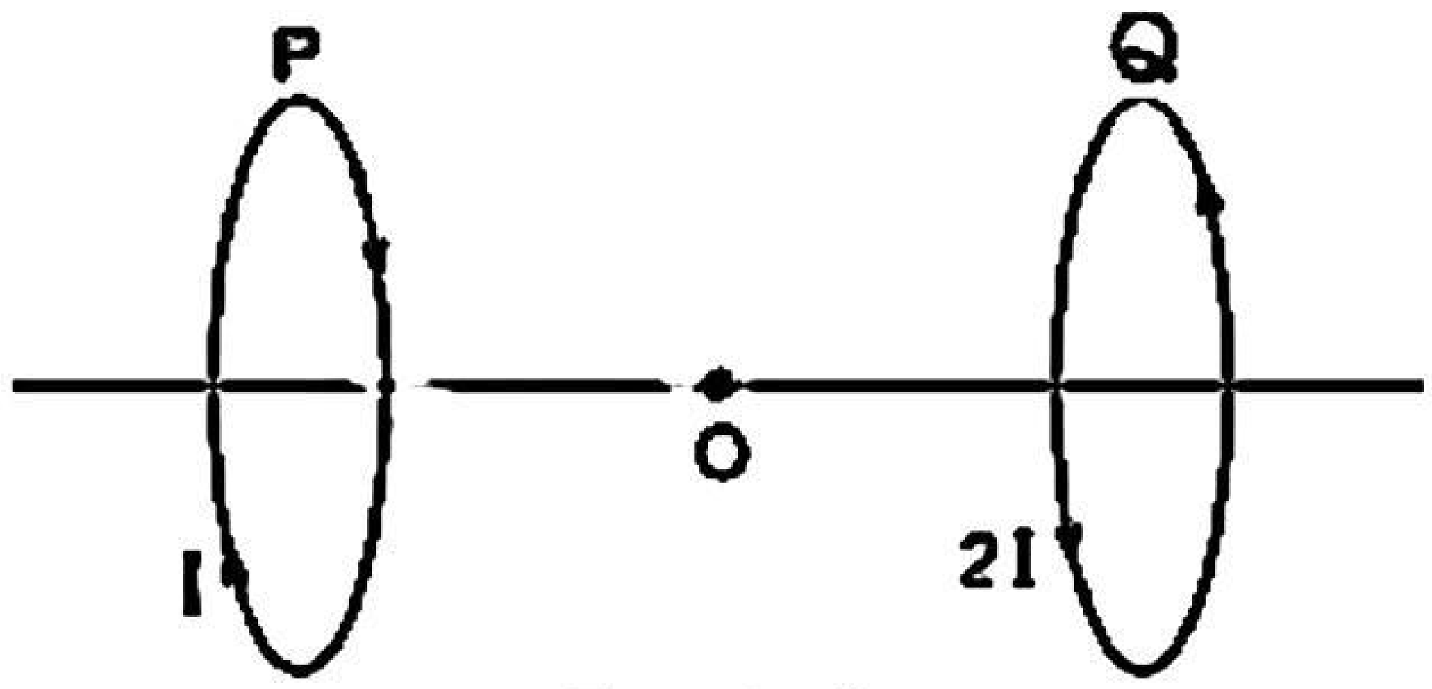

Fig. 1.42

The direction of current in both the loops is clockwise as seen from O, which is equidistant from both the loops. Find the magnitude and net magnetic field at point O.

Q.11 Two identical circular wires P and Q, each of radius r and carrying current I are kept in perpendicular planes, such that they have a common centre as shown in Fig. 1.43. Find the magnitude and direction of the net magnetic field at the common centre of the two coils.

SOLUTION

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TOPIC – Ampere's Circuital Law and Applications

Sol.1 As the observation point lies inside the solid conductor, the magnetic field produced at the observation point is not due to the total current, which passes through the conductor. To find the magnetic field at a point P at distance r (= 3 cm) due to the current carrying conductor, imagine a circular path of radius r around the conductor, such that point P lies on it. If R is the radius of the solid conductor, then current enclosed by the circular path,

$$I' = \frac{I}{\pi R^2} \times \pi r^2 = \frac{I r^2}{R^2}$$

Let B be magnetic field at point P due to the current carr-ying conductor. The magnetic field B acts tangential to the circular path and its magnitude is same at every point on it.

Therefore, according to Ampere's circuital law

$$\oint \vec{B} . \vec{dl} = \mu_0 I'$$

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

or $$B = \frac{\mu_0}{2\pi} \cdot \frac{I r}{R^2} = \frac{\mu_0}{4\pi} \cdot \frac{2 I r}{R^2}$$

Hence, I = 2A, r = 3cm = 0.3m and R =5cm =0.05m

$$\therefore \quad B = \frac{10^{-7} \times 2 \times 2 \times 0.03}{(0.05)^2} = 4.8 \times 10^{-6} T$$

Sol.2 Here, I=3 A; a = 15cm = 0.15 m

Now, $$B = \frac{\mu 0}{4\pi} . \frac{2I}{\alpha} \frac{10 - 7 \times 2 \times 3}{0.15} = 4.8 \times 10^{-6} T$$

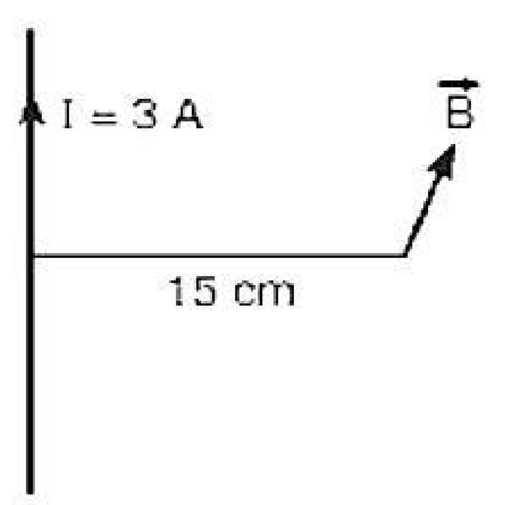

Fig. 1.31

Sol.3 It follows that $\angle PQR = \angle PRQ = 45^\circ$.

Therefore, PQ = PR = QR sin 45° = $\alpha \times \frac{1}{\sqrt{2}} = \frac{\alpha}{\sqrt{2}}$

Due to the current carrying conductor, which passes through the point Q the magnetic induction at the point p,

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2I}{PQ} = \frac{\mu_0}{4\pi} \cdot \frac{2\sqrt{2}I}{a} \quad \text{(along PR)}$$

Also, due to the current carrying conductor, which passes through the point R, the magnetic induction at the point P,

$$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2I}{PR} = \frac{\mu_0}{4\pi} \cdot \frac{2\sqrt{2}I}{a} \quad \text{(along PQ)}$$

The resultant magnetic induction at point P is given by

$$B = \sqrt{B_1^2 + B_2^2 + 2B_1B_2 \cos \pi/2} = \sqrt{B_1^2 + B_2^2}$$
$$= \frac{\mu_0}{4\pi} \cdot \frac{I}{a}\sqrt{(2\sqrt{2})^2 + (2\sqrt{2})^2} = \frac{\mu_0}{4\pi} \cdot \frac{4I}{a} = \frac{\mu_0 I}{\pi a}$$

Sol.4 Here, B = 2.52 × 10^{-3} T; μ = 4 × 10^{-7} H m^{-1}

Length of the solenoid, 1 = 0.5 m;

total number of turns in the solenoid, N = 500

Therefore, number of turns per unit length of the Solenoid

$$n = \frac{N}{l} = \frac{500}{0\cdot5} = 1{,}000 \text{ m}^{-1}$$

If is the current through the solenoid, then

$B = \mu_0 n I$

Or $I = \frac{B}{\mu 0 n} = \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-7} \times 1{,}000} = 2.0A$

Sol.5 Here, current in the solenoid, I = 5.0 A ;

length of the solenoid, I = 2.0 m

number of turns in each layer of winding = 1,000;

number of the layers of winding = 5

Therefore, total number of turns in the solenoid

N = 1,000 × 5 = 5,000

And the of turns per units length of the solenoid,

$$n = \frac{N}{l} = \frac{5,000}{2 \cdot 0} = 2,500 \text{ m}^{-1}$$

Now, $B = \mu_0 nI$

Since $\mu_0 = 4\pi \times 10^{-7}$ TA^{-1} m, we have

$B = 4\pi \times 10^{-7} \times 2,500 \times 5.0$

$= 1.57 \times 10^{-2}$ T

Sol.6 $B = \frac{\mu_0}{4\pi} \cdot \frac{2I}{a}$

Sol.7 Magnetic field lines are concentric circular loops in a plane perpendicular to the straight conductor. The centres of the circular magnetic field lines lie on the conductor.

Sol.8 The magnetic field produced by a straight solenoid is similar to that produced by a bar magnet.

Sol.9 The magnetic field at the centre of a circular coil of radius a and carrying current I is given by

$$B = \frac{B}{\mu 0n} = \frac{2\pi I}{\alpha}$$

Similarly, the magnetic field at the centre of a coil of radius a/2 and carrying current 2 I is given by

$$B' = \frac{\mu_0}{4\pi} \cdot \frac{2 \times (2I)}{a/2} = 4 \times \frac{\mu_0}{4\pi} \cdot \frac{2\pi I}{a}$$

From the equations (i) and (ii), we have

B' = 4 B

Sol.10 Magnetic field due circular wire P,

$$Bp = \frac{\mu_0}{4\pi} = \frac{2\pi I}{r}$$ (along vertically upwards)

Magnetic field due to circular wire Q

$$B_Q = \frac{\mu_0}{4\pi} \cdot \frac{2\pi(2I)}{r} = \frac{\mu_0}{4\pi} \cdot \frac{4\pi I}{r}$$

(along horizontal towards left)

Net magnetic field at the common centre of the two centre of the two coils,

$$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I}{r} = \frac{\mu_0}{4\pi} \cdot \frac{4\pi I}{r} = \frac{\mu_0}{4\pi} \cdot \frac{6\pi I}{r}$$

The direction of the net magnetic field at the common centre of the two coils will be towards left.

Sol.11

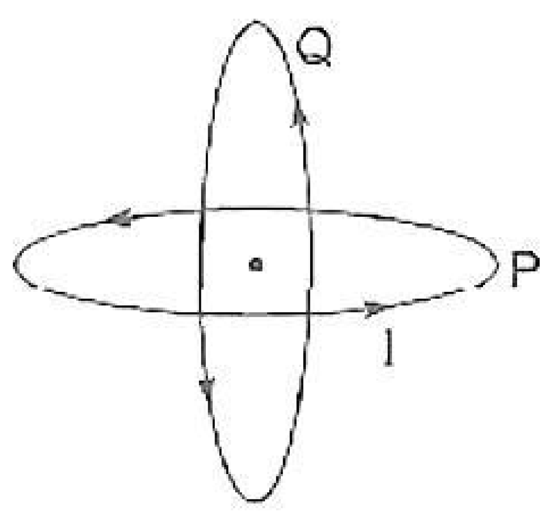

Fig. 1.43

Magnetic field due circular wire P,

$$Bp = \frac{\mu_0}{4\pi} = \frac{2\pi . I}{r}$$ (Along vertically upwards)

Magnetic field due to circular wire Q,

$$B_Q = \frac{\mu_0}{4\pi} = \frac{2\pi . I}{r}$$ (along horizontal towards left)

Net magnetic field at the common centre of the two coils,

$$B = \sqrt{B_P^2 + B_Q^2} = \sqrt{2} \times \frac{\mu_0}{4\pi} \cdot \frac{2\pi I}{r} \qquad (\therefore B_P = B_Q)$$

As the fields produced by the two coils is equal (in magnitude), the net magnetic field will be inclined equally to both the coils.