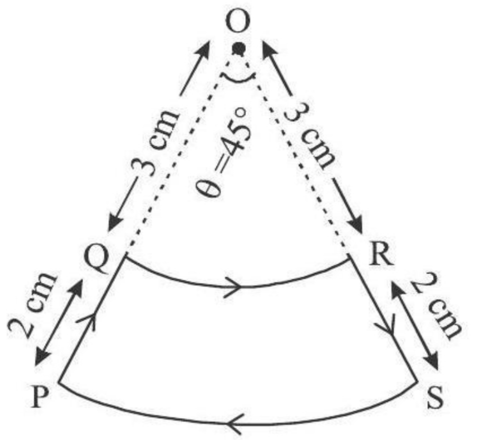
Moving Charges and Magnetism

1. A current loop, having two circular arcs joined by two radial lines is shown in the figure. It carries a current of 10 A. The magnetic field (in Tesla) at point O will be



2. A particle having the same charge as of electron moves in a circular path of radius 0.5 cm under the influence of a magnetic field of 0.5 T. If an electric field of 100 V/m makes it to move in a straight path then the mass (in kg) of the particle is (Given charge of electron $= 1.6 \times 10^{-19}$C)

3. A galvanometer having a resistance of 20Ω and 30 division on both sides has figure of merit 0.005 ampere/division. The resistance (in ohms) that should be connected in series such that it can be used as a voltmeter upto 15 volt, is:

4. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is:

5. In an experiment, electrons are accelerated, from rest, by applying a voltage of 500 V. Calculate the radius (in metre) of the path if a magnetic field 100 mT is then applied.
[Charge of the electron $= 1.6 \times 10^{-19}$C
Mass of the electron $= 9.1 \times 10^{-31}$ kg]

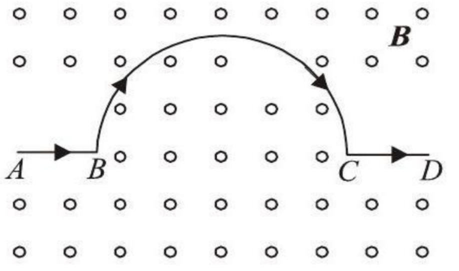
6. A galvanometer, whose resistance is 50 ohm, has 25 divisions in it. When a current of 4×10^{-4} A passes through it, its needle (pointer) deflects by one division. To use this galvanometer as a voltmeter of range 2.5 V, it should be connected to a resistance of (in ohm)

7. A rectangular coil (Dimension 5 cm × 2.5 cm) with 100 turns, carrying a current of 3 A in the clock-wise direction, is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X -axis. If the coil is tilted through 45° about Z -axis, then the torque (in Nm) on the coil is:

8. A moving coil galvanometer has resistance 50Ω and it indicates full deflection at 4 mA current. A voltmeter is made using this galvanometer and a 5kΩ resistance. The maximum voltage (in V), that can be measured using this voltmeter, will be

9. An electron accelerated by a potential difference $V = 1.0$kV moves in a uniform magnetic field at an angle $\alpha = 30°$ to the vector $\vec{B}$ whose modulus is $B = 29$mT. Find the pitch (in cm) of the helical trajectory of the electron.

10. A wire $ABCD$ is bent in the form shown here in the figure. Segments AB and CD are of length 1 m each while the semicircular loop is of radius 1 m. A current of 5 A flows from A towards the end D and the whole wire is placed in a magnetic field of 0.5 T directed out of the page. The force (in newton) acting on the wire is :

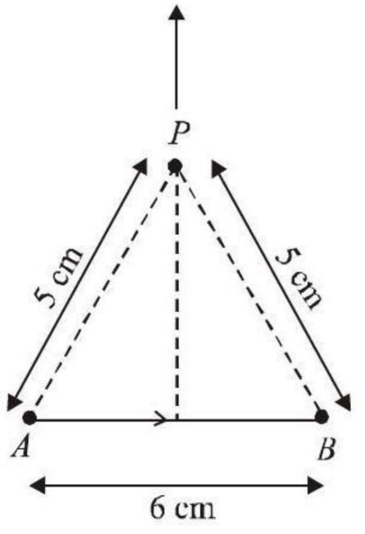


11. The resistance of a galvanometer is 50 ohm and the maximum current which can be passed through it is 0.002 A. What resistance (in ohm) must be connected to it order to convert it into an ammeter of range $0-0.5$ A ?

12. The magnitude of the magnetic field (in μT) at the center of an equilateral triangular loop of side 1 m which is carrying a current of 10 A is :
[Take $\mu_o = 4\pi \times 10^{-7} \text{NA}^{-2}$]

13. A thin ring of 10 cm radius carries a uniformly distributed charge. The ring rotates at a constant angular speed of $40\pi \text{rads}^{-1}$ about its axis, perpendicular to its plane. If the magnetic field at its centre is 3.8×10^{-9} T, then the charge (in coulomb) carried by the ring is close to ($\mu_0 = 4\pi \times 10^{-7}$ N/A^2).

14. Find the magnetic field (in Tesla) at point P due to a straight line segment AB of length 6 cm carrying a current of 5 A. (See figure) ($\mu_o = 4\pi \times 10^{-7}$ N $-$ A^{-2})



15. A 200 -turn solenoid having a length of 25 cm and a diameter of 10 cm carries a current of 0.30 A. Calculate the magnitude of the magnetic field $\vec{B}$ (in mT) inside the solenoid.

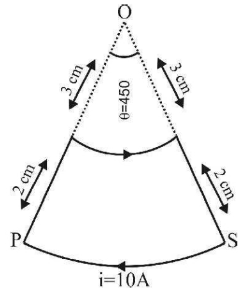
SOLUTIONS

1. **(1×10^{-5})** There will be no magnetic field at O due to wire PQ and RS

Magnetic field at 'O' due to arc QR $= \dfrac{\mu_0}{4\pi}\dfrac{\left(\frac{\pi}{4}\right).I}{r_1}$

Magnetic field at 'O' due to are PS $= \dfrac{\mu_0}{4\pi}\dfrac{\left(\frac{\pi}{4}\right).I}{r_2}$

$\therefore$ Net magnetic field at 'O'



$$B = \frac{\mu_0}{4\pi}(\pi/4)\times 10\left[\frac{1}{(3\times10^{-2})} - \frac{1}{(5\times10^{-2})}\right]$$

$$\Rightarrow |\vec{B}| = \frac{\pi}{3}\times10^{-5}T \approx 1\times10^{-5}T$$

2. **(2×10^{-24})** As particle is moving along a circular path

$\therefore \quad R = \dfrac{mv}{qB}$ ...(i)

Path is straight line, then

$qE = qvB$

$E = vB \Rightarrow \quad v = \dfrac{E}{B}$ ...(ii)

From equation (i) and (ii)

$$m = \frac{qB^2R}{E} = \frac{1.6\times10^{-19}\times(0.5)^2\times0.5\times10^{-2}}{100}$$

$\therefore \quad m = 2.0 \times 10^{-24}$ kg

3. **(80)** Deflection current

$= Ig_{max} = nxk = 0.005 \times 30$

Where, n = Number of divisions = 30 and k = 0.005 amp/division

$= 15 \times 10^{-2} = 0.15$

$v = I_g[20 + R]$

$15 = 0.15\,[20 + R]$

$100 = 20 + R$

$R = 80\,\Omega$

4. **($\sqrt{2}$)** Magnetic field at the centre of loop, $B_1 = \frac{\mu_0 I}{2R}$

Dipole moment of circular loop is m = IA

$m_1 = I.A = I.\pi R^2$ {R = Radius of the loop}

If moment is doubled (keeping current constant)

R becomes $\sqrt{2R}$

$$m_2 = I \cdot \pi\left(\sqrt{2}R\right)^2 = 2 \cdot I\pi R^2 = 2m_1$$

$$B_2 = \frac{\mu_0 I}{2\left(\sqrt{2}R\right)}$$

$$\therefore \frac{B_1}{B_2} = \frac{\frac{\mu_0 I}{2R}}{\frac{\mu_0 I}{2\left(\sqrt{2}R\right)}} = \sqrt{2}$$

5. **(7.5×10^{-4})** Radius of the path (r) is given by $r = \frac{mv}{qB}$

$$r = \frac{\sqrt{2mk}}{eB} \qquad \left(\because\ p = mv = \sqrt{2mk}\right)$$

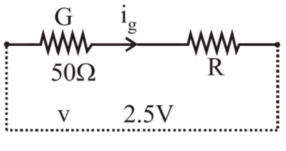
$$= \frac{\sqrt{2meV}}{eB} \qquad (\because k = eV)$$

$$r = \frac{\sqrt{\frac{2m}{e}V}}{B} = \frac{\sqrt{\frac{2 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}}(500)}}{100 \times 10^{-3}}$$

$$r = \frac{\sqrt{\frac{9.1}{0.16} \times 10^{-10}}}{10^{-1}} = \frac{3}{.4} \times 10^{-4} = 7.5 \times 10^{-4}\,m$$

6. **(200)** Galvanometer has 25 divisions

$I_g = 4 \times 10^{-4} \times 25 = 10^{-2}$ A

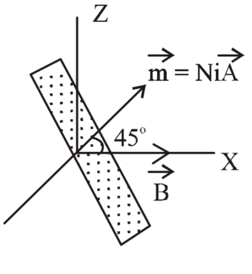


$V = I_g R_{net}$

$v = I_g(G + R)$

$2.5 = (50 + R)\,10^{-2}$ $\therefore$ R = 200Ω

7. **(0.27)** $\tau = mB \sin 45° = N(iA)B \sin 45°$



$$= 100 \times 3(5 \times 2.5) \times 10^{-4} \times 1 \times \frac{1}{\sqrt{2}} = 0.27\text{ Nm}$$

8. **(20)** $V = i_g(G + R) = 4 \times 10^{-3}$
$(50 + 5000) = 20V$

9. **(2)** If v is the velocity of the electron, then

$$\frac{1}{2}mv^2 = eV$$

$$\therefore \quad v = \sqrt{\frac{2eV}{m}}$$

$$\text{Pitch} = v\cos\alpha \times T = v\cos\alpha \times \frac{2\pi m}{eB}$$

$$= \frac{2\pi m}{eB}\sqrt{\frac{2eV}{m}}\cos\alpha$$

$$= 2\pi\sqrt{\frac{2mV}{eB^2}}\cos\alpha$$

10. **(10)** $\vec{F} = \vec{F}_{AB} + \vec{F}_{BC} + \vec{F}_{CD}$

or $F = Bi \times 1 + Bi \times 2 + Bi \times 1$
$= 4\,Bi = 4 \times 0.5 \times 5 = 10\,\text{N}$

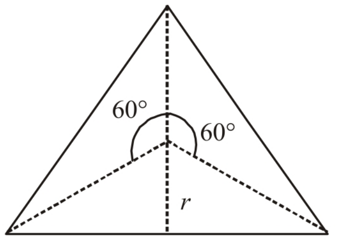
11. **(0.2)** Using, $i_g = i\dfrac{S}{S+G}$

$$0.002 = 0.5\frac{S}{S+50}$$

On solving, we get

$$S = \frac{100}{498} \simeq 0.2\,\Omega$$

12. **(18)**



$$r = \left(\frac{1}{3}\right)(a\sin 60)$$

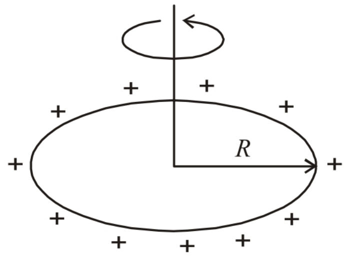
$$r = \frac{a}{3} \times \frac{\sqrt{3}}{2} = \left(\frac{a}{2\sqrt{3}}\right)$$

$$B_0 = 3\left[\frac{\mu_0 I}{4\pi r}(\sin 60 + \sin 60)\right]$$

$$= \frac{3\mu_0 I}{4\pi\left(\frac{a}{2\sqrt{3}}\right)} \times (2)\left(\frac{\sqrt{3}}{2}\right) = \frac{9}{2}\left(\frac{\mu_0 I}{\pi a}\right)$$

$$= \frac{9 \times 2 \times 10^{-7} \times 10}{1} = 18\ \mu\text{T}$$

13. **(3×10^{-5})** If q is the charge on the ring, then



$$i = \frac{q}{T} = \frac{q\omega}{2\pi}$$

Magnetic field,

$$B = \frac{\mu_0 i}{2R} = \frac{\mu_0\left(\frac{q\omega}{2\pi}\right)}{2R}$$

or $$3.8 \times 10^{-9} = \left(\frac{\mu_0}{4\pi}\right)\frac{q\omega}{R} = \left(10^{-7}\right)\frac{q \times 40\pi}{0.10}$$

$\therefore \quad q = 3 \times 10^{-5}$ C

14. **(1.5×10^{-5})** $B = \frac{\mu_0}{4\pi}, \frac{i}{r}(\sin\alpha + \sin\beta)$

Here $r = \sqrt{5^2 - 3^2} = 4$ cm

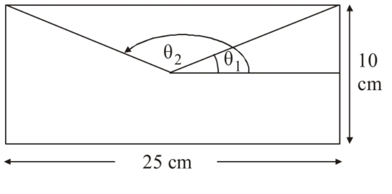
$\alpha = \beta = 37°$

$\therefore \quad B = 10^{-7} \times \frac{5}{4} 2\sin 37° = 1.5 \times 10^{-5}$ T

15. **(0.3)** The magnetic field at the centre of the solenoid is given by

$$B = \frac{\mu_0 ni}{2}(\cos\theta_1 - \cos\theta_2)$$

Here $\cos\theta_1 = 0.93$, $\cos\theta_2 = \cos(180° - \theta_1) = -\cos\theta_1$



$$\therefore \quad B = \frac{4\pi \times 10^{-7} \times \left(\frac{200}{0.25}\right) \times 0.3 \times (2 \times 0.93)}{2}$$

$$= 0.3 \text{ mT}$$