Physics

NCERT Exemplar Problems

Chapter 4

Moving Charges and Magnetism

4.1 (d)

4.2 (a)

4.3 (a)

4.4 (d)

4.5 (a)

4.6 (d)

4.7 (a), (b)

4.8 (b), (d)

4.9 (b), (c)

4.10 (b), (c), (d)

4.11 (a), (b), (d)

4.12 For a charge particle moving perpendicular to the magnetic field:

$$\frac{mv^2}{R} = qvB$$

$$\therefore \frac{qB}{m} = \frac{v}{R} = \omega \qquad \therefore [\omega] = \left[\frac{qB}{m}\right] = \left[\frac{v}{R}\right] = [T]^{-1}.$$

4.13 $dW = \mathbf{F}.d\mathbf{l} = 0 \qquad \Rightarrow \mathbf{F}.\mathbf{v}dt = 0 \qquad \Rightarrow \mathbf{F}.\mathbf{v} = 0$

F must be velocity dependent which implies that angle between **F** and **v** is 90°. If **v** changes (direction) then (directions) **F** should also change so that above condition is satisfied.

4.14 Magnetic force is frame dependent. Net acceleraton arising from this is however frame independent (non - relativistic physics)for inertial frames.

4.15 Particle will accelerate and decelerate altenatively. So the radius of path in the Dee's will remain unchanged.

4.16 At O_2, the magnetic field due to I_1 is along the y-axis. The second wire is along the y-axis and hence the force is zero.

4.17 $\mathbf{B} = \frac{1}{4}(\hat{\mathbf{i}}+\hat{\mathbf{j}}+\hat{\mathbf{k}})\frac{\mu_0 I}{2R}$

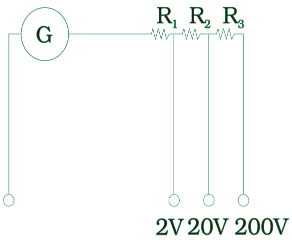
4.18 No dimensionless quantity $[T]^{-1} = [\omega] = \left[\frac{eB}{m}\right]$

4.19 $\mathbf{E} = E_0\hat{\mathbf{i}}, E_0 > 0, \mathbf{B} = B_0\hat{\mathbf{k}}$

4.20 Force due to $d\mathbf{l}_2$ on $d\mathbf{l}_1$ is zero.

Force due to $d\mathbf{l}_1$ on $d\mathbf{l}_2$ is non-zero.

4.21 $i_G (G + R_1) = 2$ for 2V range



$i_G (G + R_1 + R_2) = 20$ for 20V range

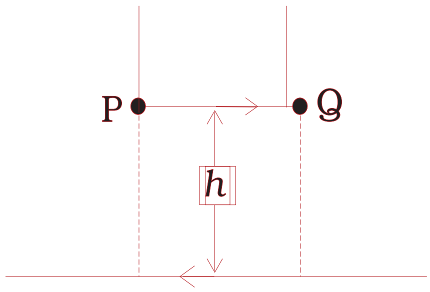
and $i_G (G + R_1 + R_2 + R_3) = 200$ for 200V range

Gives $R_1 = 1990\Omega$

$R_2 = 18\ \text{k}\Omega$

and $R_3 = 180\ \text{k}\Omega$

4.22 $F = BIl \text{ Sin } \theta = BIl$



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

$$F = mg = \frac{\mu_0 I^2 l}{2\pi h}$$

$$h = \frac{\mu_0 I^2 l}{2\pi mg} = \frac{4\pi \times 10^{-7} \times 250 \times 25 \times 1}{2\pi \times 2.5 \times 10^{-3} \times 9.8}$$

$= 51 \times 10^{-4}$

$h = 0.51$ cm

4.23 When the field is off $\sum \tau = 0$

$Mgl = W_{coil}\ l$

$500\ g\ l = W_{coil}\ l$

$W_{coil} = 500 \times 9.8$ N

When the magnetic field is switched on

$Mgl + mgl = W_{coil}\ l + IBL \sin 90° l$

$mgl = BIL\ \ l$

$$m = \frac{BIL}{g} = \frac{0.2 \times 4.9 \times 1 \times 10^{-2}}{9.8} = 10^{-3} \text{kg}$$

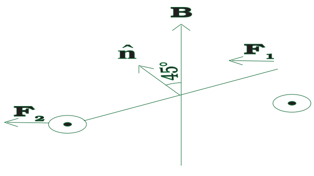
$= 1$ g

4.24 $F_1 = i_1 lB = \frac{V_0}{R} lB \quad \tau_1 = \frac{d}{2\sqrt{2}} F_1 = \frac{V_0 ldB}{2\sqrt{2}R}$

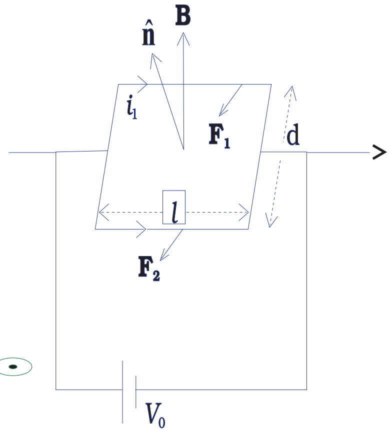
$$F_2 = i_2 lB = \frac{V_0}{2R} lB \qquad \tau_2 = \frac{d}{2\sqrt{2}} F_2 = \frac{V_0 ldB}{4\sqrt{2}R}$$

Net torque $\tau = \tau_1 - \tau_2$

$$\tau = \frac{1}{4\sqrt{2}} \frac{V_0 AB}{R}$$



Side view



Front view

4.25 As **B** is along the x axis, for a circular orbit the momenta of the two particles are in the y - z plane. Let $\mathbf{p}_1$ and $\mathbf{p}_2$ be the momentum of the electron and positron, respectively. Both of them define a circle of radius R. They shall define circles of opposite sense. Let $\mathbf{p}_1$ make an angle θ with the y axis $\mathbf{p}_2$ must make the same angle. The centres of the repective circles must be perpendicular to the momenta and at a distance R. Let the center of the electron be at Ce and of the positron at Cp. The coordinates of Ce is

The coordinates of Ce is

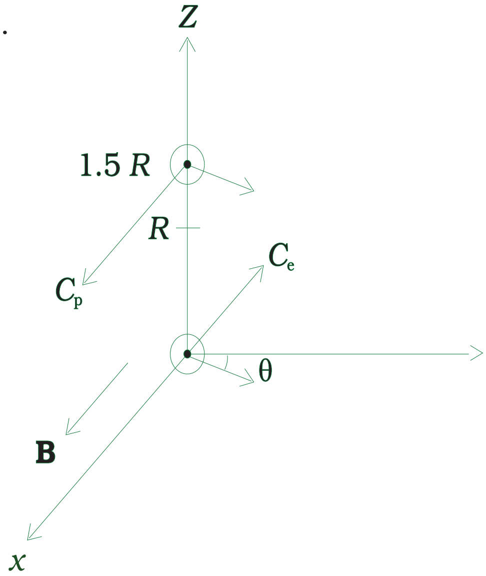
$Ce \equiv (0, -R\sin\theta,\ R\cos\theta)$

The coordinates of Cp is

$Cp \equiv (0, -R\sin\theta, \frac{3}{2}\ \mathrm{R{-}R}\cos\theta)$

The circles of the two shall not overlap if the distance between the two centers are greater than $2R$.

Let d be the distance between Cp and Ce.



Then $d^2 = (2\mathrm{R}\mathrm{Sin}\theta)^2 + \left(\frac{3}{2}\mathrm{R} - 2\mathrm{R}\cos\theta\right)^2$

y

$= 4R^2\mathrm{Sin}^2\theta + \frac{9^2}{4}\ R - 6R^2\cos\theta + 4R^2\cos^2\theta$

$= 4R^2 + \frac{9}{4}R^2 - 6R^2\cos\theta$

Since d has to be greater than $2R$

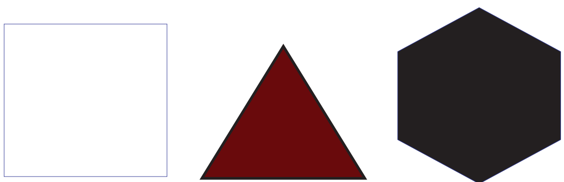
$d^2 > 4R^2$

$\Rightarrow 4R^2 + \frac{9}{4}R^2 - 6R^2\cos\theta > 4R^2$

$\Rightarrow \frac{9}{4} > 6\cos\theta$

Or, $\cos\theta < \frac{3}{8}$.

4.26



$n = 4$ $n = 3$ $n = 2$

Area: $A = \frac{\sqrt{3}}{4}a^2$ $\qquad A = a^2$ $\qquad A = \frac{3\sqrt{3}}{4}a^2$

Current I is same for all

Magnetic moment $m = n\,I\,A$

$\therefore m = Ia^2\sqrt{3}$ $\qquad 3a^2I$ $\qquad 3\sqrt{3}a^2I$

(Note: m is in a geometric series)

4.27 (a) B (z) points in the same direction on z - axis and hence J (L) is a monotonically increasing function of L.

(b) J(L) + Contribution from large distance on contour $C = \mu_0 I$

$\therefore \mathrm{as} L \to \infty$

Contribution from large distance $\to 0(\mathrm{as} B \,\square\, 1/r^3)$

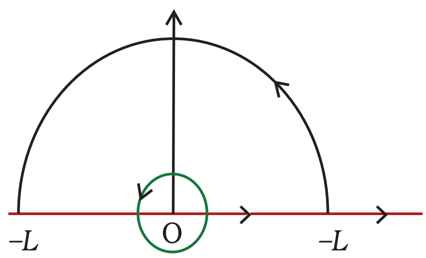
$J(\infty) - \mu_0 I$

(c) $B_z = \dfrac{\mu_0 I R^2}{2(z^2 + R^2)^{3/2}}$

$$\int_{-\infty}^{\infty} B_z dz = \int_{-\infty}^{\infty} \frac{\mu_0 I R^2}{2(z^2 + R^2)^{3/2}} dz$$

Put $z = R\tan\theta$ $\quad dz = R\sec^2\theta \, d\theta$

$$\therefore \int_{-\infty}^{\infty} B_z dz = \frac{\mu_0 I}{2} \int_{-\pi/2}^{\pi/2} \cos\theta d\theta = \mu_0 I$$



(d) $B(z)_{\text{square}} < B(z)_{\text{circular coil}}$

$\therefore \mathfrak{I}(L)_{\text{square}} < \mathfrak{I}(L)_{\text{circular coil}}$

But by using arguments as in (b)

$\mathfrak{I}(\infty)_{\text{square}} = \mathfrak{I}(\infty)_{\text{circular}}$

4.28 $i_G . G = (i_1 - i_G)(S_1 + S_2 + S_3)$ for $i_1 = 10\text{mA}$

$i_G (G + S_1) = (i_2 - i_G)(S_2 + S_3)$ for $i_2 = 100\text{mA}$

and $i_G (G + S_1 + S_2) = (i_3 - i_G)(S_3)$ for $i_3 = 1\text{A}$

gives $S_1 = 1\text{W}$, $S_2 = 0.1\text{W}$ and $S_3 = 0.01\text{W}$

4.29 (a) zero

(b) $\dfrac{\mu_0}{2\pi} \dfrac{i}{R}$ perpendicular to AO towards left.

(c) $\dfrac{\mu_0}{\pi} \dfrac{i}{R}$ perpendicular to AO towards left.