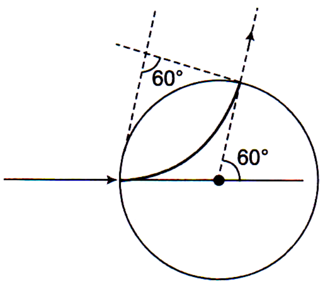
WEEKLY TEST TARGET - JEE - TEST - 24
SOLUTION Date 10-11-2019

[PHYSICS]

1. **(c)** For undeviated motion $|\vec{F_e}| = |\vec{F_m}|$, which happened when $\vec{v}, \vec{E}$ and $\vec{B}$ are mutually perpendicular to each other.

2. **(c)** Angle rotated in magnetic field = 60°



So time taken should be $\frac{1}{6}$th of time period.

$$t = \frac{T}{6} = \frac{1}{6}\left(\frac{2\pi m}{qB}\right) = \frac{\pi m}{3qB}$$

3. **(a)** Let particle completes n revolutions in time t, then $t = nT$

$$\Rightarrow \quad t = \frac{n 2\pi m}{qB}$$

If particle has to return to its initial point, then displacement along x-axis during this time should be zero.

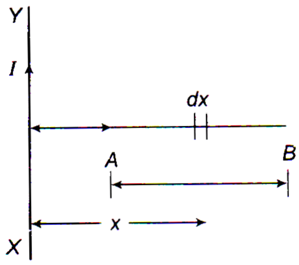
$$S_x = u_x t + \frac{1}{2} a_x t^2$$

$$\Rightarrow \quad 0 = v\cos\theta\, t - \frac{1}{2}\frac{qE}{m}t^2$$

$$\Rightarrow \quad v\cos\theta = \frac{qE}{2m}t$$

$$\Rightarrow \quad v\cos\theta = \frac{qE}{2m}\frac{n 2\pi m}{qB} \quad \Rightarrow \quad n = \frac{Bv\cos\theta}{\pi E}$$

4 **(b)** Consider an element of length dx on AB at a distance x from XY.



Force on this element, $dF = \frac{\mu_0 I}{2\pi x} idx$

Total force on $dF = \frac{\mu_0 I}{2\pi x} idx$

$$= \frac{\mu_0 Ii}{2\pi} \int_{\ell/2}^{3\ell/2} \frac{1}{x} dx = \frac{\mu_0 Ii}{2\pi} \log_e 3$$

5. **(a)** Consider an elementary strip of width dx on the sheet at a distance x from the wire.

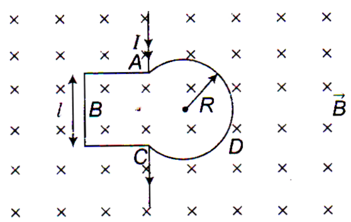
Force on this element is: $dF = \frac{\mu_0 I_1}{2\pi x} I_2 dx$

Total force on unit length of sheet is

$$F = \int_a^{a+b} \frac{\mu_0 I_1}{2\pi x} I_2 dx$$

$$F = \frac{\mu_0 I_1 I_2}{2\pi} \int_a^{a+b} \frac{1}{x} dx = \frac{\mu_0 I_1 I_2}{2\pi a} \log \frac{(a+b)}{b}$$

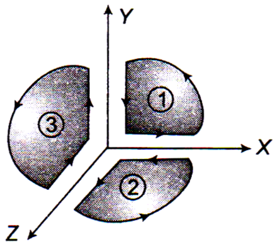
6. **(b)** $F = Bi_1 \ell + Bi_2 \ell$



$= B\ell(i_1 + i_2) = Bi\ell$

7. **(b)** The circular segments in each of the quadrants can be considered individually for calculating the mag-

netic magnet. Thus, segments in each of the quadrants are considered as loops individual by joining the two ends hypothetically in the same plane. When all the three segments are considered together, the contribution by hypothetical elements are cancelled.



$$M_1 = i\left(\frac{\pi a^2}{4}\right)\hat{k}$$

Similarly, $M_2 = i\left(\frac{\pi a^2}{4}\right)\hat{j}$

$$M_3 = i\left(\frac{\pi a^2}{4}\right)\hat{i}$$

So, net magnetic moment

$$\vec{M} = \vec{M}_1 + \vec{M}_2 + \vec{M}_3$$

$$\vec{M} = \frac{\pi a^2 i}{4}(\hat{i} + \hat{j} + \hat{k})$$

8. a

9. **(c)** $B_{AB} = \frac{\mu_0 I}{4\pi(OC)}[2\sin\theta]$

But $OC = r\cos\theta$

or $B_{AB} = \frac{\mu_0 I}{2\pi r}\tan\theta$

Magnetic field due to circular portion.

$$B_{AB}' = \frac{\mu_0 I}{2r}\frac{2\pi - 2\theta}{2\pi} = \frac{\mu_0 I}{2\pi r}(\pi - 0)$$

Total magnetic field

$$= \frac{\mu_0 I}{2\pi r}\tan\theta + \frac{\mu_0 I}{2\pi r}(\pi - \theta)$$

$$= \frac{\mu_0 I}{2\pi r}[\tan\theta + \pi - \theta]$$

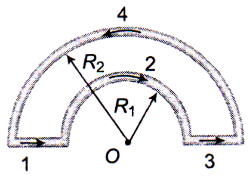
10. **(b)** The given shape is equivalent to the following diagram

The field at O due to straight part of conductor is $B_1 = \frac{\mu_o}{4\pi} \cdot \frac{2i}{r}\odot$. The field at O due to circular coil is $B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r}\otimes$. Both fields will act in the opposite direction, hence the total field at O.

i.e., $B = B_2 - B_1 = \left(\frac{\mu_o}{4\pi}\right) \times (\pi - 1)\frac{2i}{r} = \frac{\mu_o}{4\pi} \cdot \frac{2i}{r}(\pi - 1)$

11. **(d)** $B = \frac{\mu_0}{4\pi}\frac{(2\pi - \theta)i}{R} = \frac{\mu_0}{4\pi}\frac{\left(2\pi - \frac{\pi}{2}\right)\times i}{R} = \frac{3\mu_0 i}{8R}$

12. **(a)** In the following figure, magnetic fields at O due to sections 1, 2, 3 and 4 are considered as B_1, B_2, B_3 and B_4 respectively.



$B_1 = B_3 = 0$

$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_1}\otimes$

$B_4 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_2}\odot$ As $|B_2| > |B_4|$

So $B_{net} = B_2 - B_4 \Rightarrow B_{net} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\otimes$

13. **(b)** $B = \frac{3}{4}\left[\frac{\mu_0 I}{2a}\right] + \frac{1}{4}\left[\frac{\mu_0 I}{2b}\right]$

$B = \frac{3\mu_0 I}{8a} + \frac{\mu_0 I}{8b}$

14.

15. **(b)** Distance of straight conductor from

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

Or $B = \frac{\mu_0 I}{4\pi} + \frac{2I}{r}\left[\sqrt{2}\frac{\pi}{4}\right].$

16. **(d)** For cylinder :

$$B = \frac{\mu_0 i r}{2\pi R^2}; r < a$$

$$= \frac{\mu_0 i}{2\pi R^2}; r \geq a$$

We can consider the given cylinder as a combination of two cylinders. One of radius 'R' carrying current I in one direction and other of radius $\frac{R}{2}$ carrying current $\frac{I}{3}$ in both directions.

At point A: $B = \frac{\mu_0 (1/3)}{2\pi (R/2)} + 0 = \frac{\mu_0 I}{3\pi R}$

At point B: $B = \frac{\mu_0}{2\pi}\left(\frac{4I/3}{\pi R^2}\right)\left(\frac{R}{2}\right) + 0 = \frac{\mu_0 I}{3\pi R}$

17. **(b)** $B = \frac{\mu_0}{4\pi}\frac{2M}{x^3} = \frac{\mu_0}{4\pi}\frac{i\pi r^2}{(r/\sin\theta)^3}$

$$\Rightarrow B \propto \frac{i}{r} B_1 = B_2 \Rightarrow \frac{i_1}{r_1} = \frac{i_2}{r_2} \Rightarrow \frac{i_1}{i_2} = \frac{r_1}{r_2}$$

18. **(c)** By Lenz's law clockwise current is induced in closed loop. Hence direction of current $a \to b \to d \to c$.

19. **(b)** Effective length between A and B remains same.

20. **(b)** Equivalent resistance of the given Wheatstone bridge circuit (balanced) is 3W so total resistance in circuit is $R = 3 + 1 = 4\Omega$. The emf induced in the loop $e = Bvl$.

So induced current $i = \frac{e}{R} = \frac{Bvl}{R}$

$$\Rightarrow 10^{-3} = \frac{2 \times v \times (10 \times 10^{-2})}{4} \Rightarrow v = 2\,\text{cm/sec}.$$

21. Both points A and B lying on the axis of the magnet and on axial position

$$B \propto \frac{1}{d^3} \Rightarrow \frac{B_A}{B_B} = \left(\frac{d_B}{d_A}\right)^3 = \left(\frac{48}{24}\right)^3 = \frac{8}{1}$$

24. $B = 10^{-7} \times \frac{2i}{r} = 10^{-7} \times \frac{2 \times 1}{1} = 2 \times 10^{-7}\,T$

25. $\tau_{max} = MB$ or $\tau_{max} = ni\pi r^2 B$. Let number of turns in length l is n so $l = n(2\pi r)$ or $\alpha = \frac{l}{2\pi n}$

$$\Rightarrow \tau_{max} = \frac{ni\pi B l^2}{4\pi^2 n^2} = \frac{l^2 iB}{4\pi n_{min}} \Rightarrow \tau_{max} \propto \frac{1}{n_{min}} \Rightarrow n_{min} = 1$$