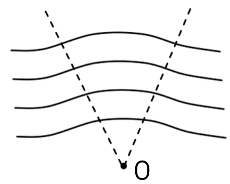
Magnetism

1. If the magnetic lines of force are shaped like arcs of concentric circles with their centre at point O in a certain section of a magnetic field:



(A) The intensity of the field in this section should at each point be inversely proportional to its distance from point O.

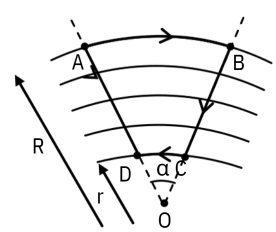
(B) The intensity of the field in this section should at each point be inversely proportional to square of its distance from point O.

(C) The intensity of the field in this section should at each point be inversely proportional to cube of its distance from point O.

(D) Nothing can be said.

Answer: [A]

To prove this we will calculate work done by electric force in a close loop ABCD.



During displacement AD and BC work done by electric force = 0 as electrostatic is perpendicular to displacement.

Work done during AB = $R\alpha E1$

Work done during CD = $-r\alpha E2$

Total work done = $R\alpha E1 - r\alpha E2$

Close loop work done should be zero

$\therefore \frac{E1}{E2} \frac{r}{R} =$

2. A magnet is suspended horizontally in the earth's magnetic field. When it is displaced and released, it oscillates in a horizontal plane with a period T. If a piece of wood of same M.I as the magnet is attached to the magnet is attached to the magnet, the new period of oscillation of the system would be -

(A) $\frac{T}{3}$ (B) $\frac{T}{2}$ (C) $\frac{T}{\sqrt{2}}$ (D) $\sqrt{2}T$

Answer: [D]

$T = 2\pi \sqrt{\frac{I}{MBH}}$

$T' = 2\pi \sqrt{\frac{2I}{MBH}} = \sqrt{2}T$

3. A paramagnetic material of magnetic susceptibility 2×10^{-5} is placed in magnetic field 0.1×1^{-4} Am^{-1}. The intensity of magnetization of material in unit Am^{-1} is

a) 4×10^{-10}
b) 3×10^{-10}
c) 2×10^{-10}
d) 5×10^{-8} m

Answer: (c)

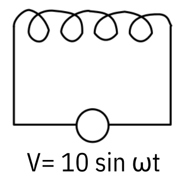
Explanation:

$\chi_m = \frac{I}{H} \Rightarrow I = \chi_m \times H$

$= 2 \times 10^{-5} \times 0.1 \times 10^{-4}$

$= 2 \times 10^{-10}$ A/m

4. If a Bismuth rod is introduced in the air coil as shown then current in the coil -



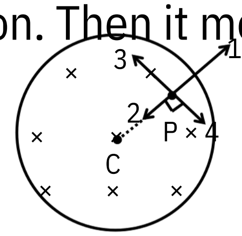
(A) increases (B) remains unchanged
(C) decreases (D) none of these

Answer: [A]

L will decrease as Bi is diamagnetic

$I = \frac{V}{X_L}$ will increase

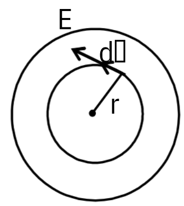
5. A uniform but time varying magnetic field exists in cylindrical region and directed into the paper. If field decrease with time and a positive charge placed at any point inside the region. Then it moves -



(A) along 1 (B) along 2 (C) along 3 (D) along 4

Answer: [C]

$\int E.dl = -\pi r^2 \frac{dB}{dt}$



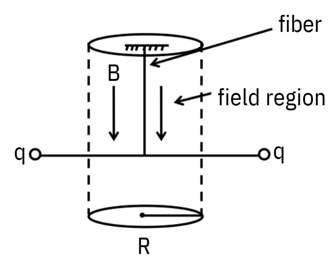
$E \times 2\pi r = +\pi r^2 \times \frac{dB}{dt}$ as $\frac{dB}{dt} = -ve$

E = +ve

∴ assume direction is right

so q charge move along 3.

6. Two small pith balls, each carrying a charge q are attached to the ends of a light rod of length d, which is suspended from the ceiling by a thin torsion free fiber as shown in figure. There is a uniform magnetic field B pointing straight down, in the cylindrical region of radius R around the fiber. The system is initially at rest. If the magnetic field is turned off. Which of the following happen to the system -



(A) It rotate with an angular momentum qBR^2

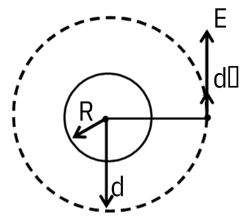
(B) It does not move at all

(C) It rotate with an angular momentum $\frac{qBR^2}{2}$

(D) None of the above

Answer: [C]

$\frac{d\varphi}{dt} = \int E.d\ell$



$\pi R^2 \frac{dB}{dt} = E \times 2\pi d$

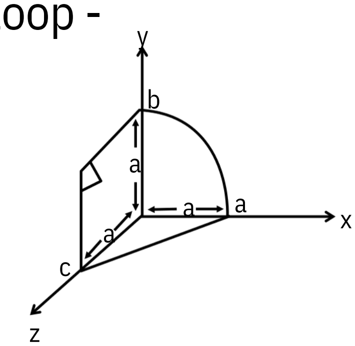
$E = \frac{R^2}{2d}\frac{dB}{dt} = \frac{R^2}{2d}\frac{B}{\Delta t}$

Change in angular momentum of whole system

$= \tau \times \Delta t \times 2$

$= qE \times \frac{d}{2} \times \Delta t \times 2 = \frac{qBR^2}{2}$

7. In given figure, a wire loop has been bent so that it has three segments ab (a quarter circle), bc (a square corner) & ca (straight line). Here are three choices for a magnetic field through the loop -



(1) $\vec{B}_1 = 3\hat{i} + 7\hat{j} - 5t\hat{k}$

(2) $\vec{B}_2 = 5t\hat{i} - 4\hat{j} - 15\hat{k}$

(3) $\vec{B}_3 = 2\hat{i} - 5t\hat{j} - 12\hat{k}$

Where B is in milli tesllas and t is in second if the induced current in the loop due to $\vec{B}_1, \vec{B}_2, \vec{B}_3$ are i_1, i_2, i_3 respectively then -

(A) $i_1 > i_2 > i_3$

(B) $i_2 > i_1 > i_3$

(C) $i_3 > i_2 > i_1$

(D) $i_1 = i_2 = i_3$

Answer: [B]

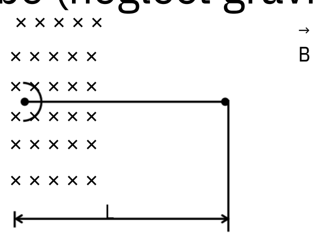
$i_1 = \frac{d\varphi_1}{dt} \times \frac{1}{R} = \frac{d[B_1 \times \text{Area}]}{R\,dt} = \frac{d}{dt}\left[5t \times \frac{\pi a^2}{4}\right] \times \frac{1}{R} = \frac{5\pi a^2}{4R}$

$i_2 = \frac{d\varphi_2}{dt} \times \frac{1}{R} = \frac{d[5a^2t]}{dt} \times \frac{1}{R} = \frac{5a^2}{R}$

$i_3 = \frac{d\varphi_3}{dt} \times \frac{1}{R} = \frac{d[0.5a^2t]}{dt} \times \frac{1}{R} = \frac{a^2}{2R}$

$\therefore i_2 > i_1 > i_3$

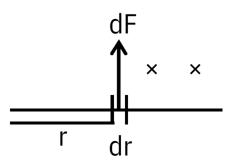
8. Straight conductor of mass m and carrying a current i is hinged at one end and placed in a plane perpendicular to the magnetic field B as shown in figure. At any moment if the conductor is let free, then the angular acceleration of the conductor will be (neglect gravity) -



(A) $\frac{3iB}{2m}$ (B) $\frac{2}{3}\frac{iB}{m}$ (C) $\frac{iB}{2m}$ (D) $\frac{3i}{2mB}$

Answer: [A]

Torque

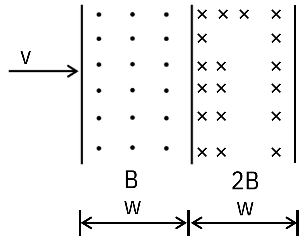


$d\tau = dF \times r = iBdr \times r$

$\tau = \int_0^L iBr\,dr = \frac{iBL^2}{2}$

$\alpha = \frac{\tau}{I} = \frac{iBL^2/2}{mL^2/3} = \frac{3}{2}\frac{iB}{m}$

9. The magnetic field shown in the figure consist of the two magnetic fields.

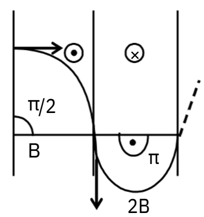


If v is the velocity just required for a charge particle of mass m and charge q to pass through the magnetic field. Particle is projected with velocity "v" then how much time does such a charge spend in the magnetic field -

(A) $\frac{\pi m}{2qB}$ (B) $\frac{\pi m}{qB}$ (C) $\frac{\pi m}{4qB}$ (D) $\frac{3\pi m}{2qB}$

Answer: [B]

Time = $\frac{\pi m}{2qB} + \frac{\pi m}{2qB} = \frac{\pi m}{qB}$



10. A charged particle is moving in a circular orbit of radius 6cm with a uniform speed of 3×106m/s under the action of uniform magnetic field 2×10−4Wb/m2 at right angles to the plane of the orbit. The charge to mass ratio of the particle is

(A) 5×109C/kg (B) 2.5×1011C/kg
(C) 5×1011C/kg (D) 5×1012C/kg

Answer: (B)

Here, υ=3×106ms−1

B=2×10−4Wbm−2=2×10−4T

R=6cm=6×10−2m

As $Bq\upsilon = \frac{m\upsilon2}{R}$ or $\frac{q}{m} = \frac{\upsilon}{BR}$

Substituting the given values, we get

$\frac{q}{m} = \frac{3\times10^6}{2\times10^{-4}\times6\times10^{-2}} = 0.25\times10^{12}$ C/kg

$= 2.5\times10^{11}$ C/kg

11. A specimen of iron of permeability 8×10^{-3} weber/amp × metre is placed in a magnetic field of strength 160 amp/metre. Then magnetic induction in this iron is -

(A) 20×10^3 wb/m2 (B) 1.28 wb/m2

(C) 5×10^{-5} wb/m2 (D) 0.8 wb/m2

Answer: [B]

$\mu = 8 \times 10^{-3}$, H = 160, B = μH = 1.28 wb/m2

12. A ferromagnetic material is placed in an external magnetic field. The size of magnetic domains -

(A) decreases only

(B) increases only

(C) sometimes increases and sometimes decreases

(D) remains unchanged only

Answer: [C]

Some domains increased which are in the direction of applied field, other decrease.

13. The magnetic susceptibility of a paramagnetic substance at –73°C is 0.0060, then its value at –173°C will be -

(A) 0.0030 (B) 0.0120 (C) 0.0180 (D) 0.0045

Answer: [B]

$\chi_m \propto \frac{1}{T} \Rightarrow \frac{\chi_1}{\chi_2} = \frac{T_2}{T_1} = \frac{100}{200} = \frac{1}{2}, \chi_2 = 2\chi_1$

14. A compass needle placed at a distance r from a short magnet in tanA position shows a deflection of 60°. If the distance is increased to r(3)1/3, then the deflection of the compass needle is -

(A) 30°

(B) 60° × (3)1/3

(C) 60° × (3)2/3

(D) 60° × (3)3/3

Answer: [A]

In tan A position $\frac{2kM}{r^3} = B_H \tan\theta$

$\left(\frac{r_1}{r_2}\right)^3 = \frac{\tan\theta_2}{\tan\theta_1} \Rightarrow \theta_2 = 30°$

15.A magnetic needle of negligible breadth and thickness compared to its length, oscillates in a horizontal plane with a period T. The period of oscillation of each part obtained on breaking the magnet into n equal parts and perpendicular to the length is -

(A) T (B) T/n (C) Tn (D) 1/Tn

Answer: [B]

$T = 2\pi\sqrt{\frac{I}{MB}}$

on breaking n equal parts perpendicular to length

$I' = \frac{1}{12}\left(\frac{m}{n}\right)\left(\frac{l}{n}\right)^2$ of each part

$I' = \frac{I}{n^3}, M' = \frac{M}{n}$

$\frac{T'}{T} = \sqrt{\frac{I'M}{M'I}} = \sqrt{\frac{1}{n^3} \times n} = \frac{1}{n} \Rightarrow T' = \frac{T}{n}$

16.The tangent galvanometers having coils of the same radius are connected in series. A current flowing in them produces deflections of 60° and 45° respectively. The ratio of the number of turns in the coil is -

(A) (4/3) (B) ($\sqrt{3}$ + 1)/1 (C) $\left(\frac{\sqrt{3}+1}{\sqrt{3}-1}\right)$ (D) $\sqrt{3}/1$

Answer: [D]

In series current is same. In tangent galvanometer

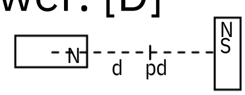
$B = B_H \tan\theta \Rightarrow \frac{\mu_0 n i}{2R} = B_H \tan\theta$

∵ i = Same ∴ n ∝ tanθ ⇒ $\frac{n_1}{n_2} = \frac{\tan 60^\circ}{\tan 45^\circ} = \frac{\sqrt{3}}{1} = \sqrt{3}$

17. Two identical short bar magnets each having magnetic moment M are placed at a distance of 2d with their axes ⊥ to each other in a horizontal plane. The magnetic induction at a point midway between them is -

(A) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ (B) $\frac{\mu_0}{4\pi}\frac{(\sqrt{3})M}{d^3}$ (C) $\left(\frac{2\mu_0}{4\pi}\right)\frac{M}{d^3}$ (D) $\frac{\mu_0}{4\pi}\frac{(\sqrt{5})M}{d^3}$

Answer: [D]



At P $B_{net} = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left(\frac{2kM}{d^3}\right)^2 + \left(\frac{kM}{d^3}\right)^2} = \frac{kM}{d^3}(\sqrt{5})$

18. There is magnetic material of coercivity 2×10^3 A/m. What current should flow through solenoid of length 15 cm having 150 turns to demagnetise the substance completely?

(A) 4 A (B) 2.5 A (C) 2 A (D) 3.5 A

Answer: [C]

$H = 2 \times 10^3$, for solenoid H = n i

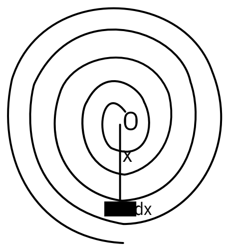
$n = \frac{150}{15 \times 10^{-2}} = 1000$

$\Rightarrow i = \frac{H}{n} = \frac{2\times10^3}{10^3} = 2A$

19. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. When a current I passes through the coil, the magnetic field at the centre is -

(A) $\frac{\mu_0 NI}{b}$ (B) $\frac{2\mu_0 NI}{a}$ (C) $\frac{\mu_0 NI}{2(b-a)}\log\frac{b}{a}$ (D) $\frac{\mu_0 IN}{2(b-a)}\log\frac{a}{b}$

Answer: [C]



An element is assumed at distance x from center whose width is dx. No. of turns in width b−a = N

$\therefore$ No. of turns is width dx = $n = \left(\frac{N}{b-a}\right)dx$

$dB = \frac{\mu_0 n i}{2x} = \frac{\mu_0 i N dx}{2(b-a)\,x}$

$\therefore B = \frac{\mu_0 i N}{2(b-a)}\int_a^b \frac{dx}{x} = \frac{\mu_0 N i}{2(b-a)}\log\left(\frac{b}{a}\right)$

20. When a magnet is suspended at an angle 30º from the magnetic meridian, it makes an angle 45º with horizontal. What will be the actual angle of dip?

(A) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (B) $\tan^{-1}(\sqrt{3})$ (C) 45º (D) 30º

Answer: [A]

$\tan\varphi' = \frac{\tan\varphi}{\cos\alpha} \Rightarrow \tan 45^\circ = \frac{\tan\varphi}{\cos 30^\circ}$

$\varphi = \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

21. The magnetic needle of a vibration magnetometer makes 12 oscillations per minute in the horizontal component of earth's magnetic field. When an external short bar magnet is placed at some distance along the axis of the needle in the same line, it makes 15 oscillations per minute. If the poles of the bar magnet are interchanged, the number of oscillations it makes per minute is-

(A) $6\sqrt{1}$ (B) $6\sqrt{3}$ (C) $6\sqrt{5}$ (D) $6\sqrt{7}$

Answer: [B]

Magnetic field = B_H $T = \frac{60}{12} = 5$ sec.

Magnetic field = $B_H + B$ $T = \frac{60}{15} = 4$ sec.

Let after reversing magnetic needle makes x oscillation/sec.

$\Rightarrow$ Magnetic field = $B_H - B$, $T = \frac{60}{x}$ sec.

$T \propto \frac{1}{\sqrt{\text{Magnetic field}}}$ $\Rightarrow \frac{5}{4} = \sqrt{\frac{B_H + B}{B_H}}$

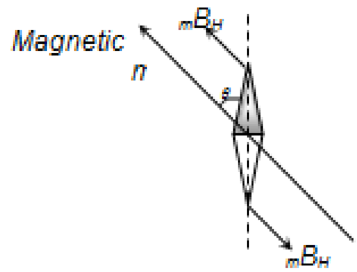
$\Rightarrow \frac{B}{B_H} = \frac{9}{16} \Rightarrow \frac{5}{(60/x)} = \sqrt{\frac{B_H - B}{B_H}}$

$\Rightarrow x = 6\sqrt{3}$

22. A compass needle whose magnetic moment is 60 $amp \times m^2$ pointing geographical north at a certain place, where the horizontal component of earth's magnetic field is 40 $\mu Wb/m^2$, experiences a torque 1.2×10^{-3} N×m. What is the declination at this place

(A) 30° (B) 45° (C) 60° (d) 25°

Answer: [A]



As the compass needle is free to rotate in a horizontal plane and points along the magnetic meridian,

So, when it is pointing along the geographic meridian, it will experience a torque due to the horizontal component of earth's magnetic field *i.e.* $\tau = MBH \sin\theta$

Where θ = angle between geographical

and magnetic meridians called angle of declination

So, $\sin\theta = \frac{1.2\times10^{-3}}{60\times40\times10^{-6}} = \frac{1}{2} \Rightarrow \theta = 30^{o}$

23. A coil made of copper suspended from a fixed support is oscillating freely. If a magnetic dipole is brought near the coil, the coil will

(a) Slow down

(b) Move faster

(c) Move faster or slow down depending on which magnetic pole is facing the coil

(d) Continue moving unaffected

Answer: (a)

When the magnet is brought near the coil due to relative motion between them, an emf is induced in the coil which according to lenz's law is in such a direction as to oppose the relative motion between them. The coil will, therefore slow down, and come to rest

24. Due to a small magnet intensity at a distance x in the end on position is 9 Gauss. What will be the intensity at a distance $\frac{x}{2}$ on broad side on position

(A) 9 *Gauss* (B) 4 *Gauss*
(C) 36 *Gauss* (D) 4.5 *Gauss*

Answer: [C]

In C.G.S. $B_{axial} = 9 = \frac{2M}{x^3}$ .....(i)

$B_{equaterial} = \frac{M}{\left(\frac{x}{2}\right)^3} = \frac{8M}{x^3}$ .....(ii)

From equation (i) and (ii) $B_{equaterial} = 36$ *Gauss*.

25. The magnetic moment produced in a substance of 1 gm is 6×10^{-7} ampere–metre^2. If its density is $5 gm/cm^3$, then the intensi of magnetisation in A/m will be

(A) 8.3×10^{6} (B) 3.0 (C) 1.2×10^{-7} (D) 3×10^{-6}

Answer: [B]

$I = \frac{M}{V} = \frac{M}{mass/density}$,

given mass = $1gm = 10^{-3} kg$,

and density $= 5 gm/cm^3 = \frac{5\times10^{-3} kg}{(10^{-2})^3 m^3} = 5\times10^{3} kg/m^3$

Hence, $I = \frac{6\times10^{-7}\times5\times10^{3}}{10^{-3}} = 3$

26. Which of the following magnetic material is temperature dependent?
   (a) Diamagnetism
   (b) Paramagnetism
   (c) Paaramagnetism
   (d) None of these

Answer: (b)

Paramagnetism depends upon temperature. Above the Curie temperature, the material becomes paramagnetic.

27. Magnetic susceptibility of a substance is– 0.925. What is it's the relative permeability ?
   (a) 1.935 (b) 0.075
   (c) 0.175 (d) 2.375

Answer: (b)

As we know that relation between magnetic susceptibility and relative permeability

$\mu_r = 1 + \chi_m$;

$\mu_r = 1 - 0.925 = 0.075$

28. Susceptibility of *Mg* at 300 *K* is $1.2\times10-5$. The temperature at which susceptibility will be $1.8\times10-5$ is
   (A) 450 *K* (B) 200 *K*
   (C) 375 *K* (D) None of these

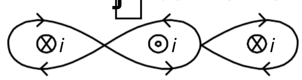
Answer: [B]

$\chi \propto \frac{1}{T}$

$\therefore \chi_1 T_1 = \chi_2 T_2$

Hence $T_2 = \frac{1.2\times10^{-5} \times 300}{1.8\times10^{-5}} = 200K$

29. Find $\oint \vec{B}.\vec{dl}$ over following loops.



a) $2\mu_0 i$

b) $-2\mu_0 i$

c) $3\mu_0 i$

d) $-3\mu_0 i$

Answer: (c)

Explanation:

According to Ampere's Circuital Law integral of magnetic field density (B) along an imaginary closed path is equal to the product of current enclosed by the path and permeability of the medium.

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

$\oint \vec{B}.\vec{dl} = \mu_0 i + \mu_0 i + \mu_0 i = 3 \mu_0 i$

30. The magnet of vibration magnetometer is heated so as to reduce its magnetic moment by 36%. By doing this the periodic time of the magnetometer will

(A) Increases by 36%
(B) Increases by 25%
(C) Decreases by 25%
(D) Decreases by 64%

Answer: [B]

$T = 2\pi\sqrt{\frac{I}{MBH}} \Rightarrow T \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}}$

If $M_1 = 100$ then $M_2 = (100 - 36) = 64$

So $\frac{T_1}{T_2} = \sqrt{\frac{64}{100}} = \frac{8}{10} \Rightarrow T_2 = \frac{10}{8} T_1 = 1.25 T_1$

So % increase in time period = 25%

31. The ratio of magnetic moments of two bar magnet is 13 : 5. These magnets are held together in a vibration magnetometer are allowed to oscillate in earth's magnetic field with like poles together 15 oscillation per minute are made. What will be the frequency of oscillation of system if unlike poles are together

(A) 10 *oscillations/min*
(B) 15 *oscillations/min*
(C) 12 *oscillations/min*
(D) $7\frac{5}{13}$ *oscillations/min*

Answer: [A]

$\frac{M_1}{M_2} = \frac{\nu_s^2 + \nu_d^2}{\nu_s^2 - \nu_d^2} \Rightarrow \frac{13}{5} = \frac{(15)^2 + \nu_d^2}{(15)^2 - \nu_d^2}$

$\Rightarrow \nu_d = 10$ *Oscillations/min*

32. Assertion: The earth's magnetic field departs from its dipole shape at very large distance.

Reason: At large distance, the field gets modified due to the field of ions in motion in the earth's ionosphere.

a) If both Assertion & Reason are true and the reason is the correct explanation of the assertion.
b) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion.
c) If Assertion is true statement but Reason is false.
d) If both Assertion and Reason are false statements.

Answer: (a)

Explanation: The earth's magnetic field departs from its dipole shape at very large distance and : At large distance, the field gets modified due to the field of ions in motion in the earth's ionosphere

33. A short bar magnet produces a magnetic induction of 4×10^{-5} T at an axial point 10 cm from its centre. It’s dipole moment is ($\mu_0 = 4\pi \times 10^{-7}$ Wb/AM)

a) 0.2 Am^2 b) 2×10^{-5} Am^2

c) 2 Am^2 d) None of these

Answer: (a)

Explanation:

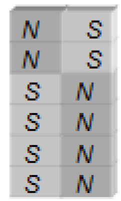
At an axial point $B = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

$$\therefore \quad 4\times10^{-5} = \frac{10^{-7}\times 2M}{0.001}$$

$$M = \frac{4\times10^{-5}\times0.001}{2\times10^{-7}}$$

= 0.2 Am^2

34. The length of *a* magnet is large compared to it's width and breadth. The time period of its oscillation in a vibration magnetometer is *T*. The magnet is cut along it’s length into six parts and these parts are then placed together as shown in the figure. The time period of this combination will be



(A) T (B) $\frac{T}{\sqrt{3}}$ (C) $\frac{T}{2\sqrt{3}}$ (D) Zero

Answer: [C]

$T = 2\pi\sqrt{\frac{I}{MH}}$; MI of each part $= \frac{I}{6^3}$

and magnetic moment of each part $M = \frac{M}{6}$

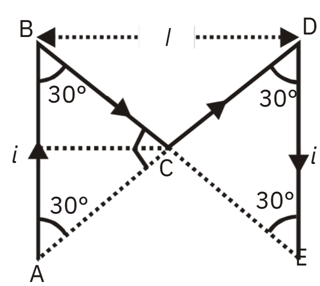
So net MI of system $= \frac{I}{6^3}\times 6 = \frac{I}{6^2}$

And net magnetic moment $= \frac{4M}{6} - \frac{2M}{6} = \frac{M}{3}$

∴ Time period of the system

$$T' = 2\pi\sqrt{\frac{I/36}{(M/3)H}} = \frac{1}{2\sqrt{3}}\,2\pi\sqrt{\frac{I}{MH}} = \frac{T}{2\sqrt{3}}$$

35. The magnetic field at point ‘c’ due to current flowing in ‘M’ shape figure is:



(A) $\frac{\mu_0}{2\pi}\frac{\sqrt{3}i}{l}$ (B) $\frac{\mu_0}{\pi}\cdot\frac{i}{l}\sqrt{3}$ (C) zero (D) $\frac{\mu_0}{4\pi}\cdot\frac{i}{l\sqrt{3}}$

Answer: [B]

$\beta = 2\left[\frac{\mu_0 I}{4\pi d}[\sin\alpha + \sin\beta]\right]$

$\alpha = \beta = 60^o$

$d = \frac{\ell}{2}$

$\beta = 2\left[\frac{\mu_0 i}{4\pi\left(\frac{\ell}{2}\right)}[2\sin 60]\right]$

$B - D\ \frac{\mu_0 i\sqrt{3}}{\pi\ell}$.

36. Magnetic field induction due to an infinite long solid cylindrical conductor of radius R at a distance $x<R$ and $y>R$ are equal in magnitude then

(A) $xy=R^2$ (B) $xy=R$ (C) $x=y$ (D) $x=\frac{R}{y}$

Answer: [A]

$x>R,\ B=\frac{\mu_0}{4\pi}\frac{2I}{x}$

$y<R,\ B'=\frac{\mu_0 2Iy}{4\pi R^2}$

But $B=B'$

$\Rightarrow xy=R^2$

37. A solenoid has an inductance of 10 henry and a resistance of 2Ω. It is connected to a 10V battery. The time taken by the magnetic energy to reach $\left(\frac{1}{4}\right)^{th}$ of its maximum value is

(ln 2 = 0.7)

(A) 2 s (B) 3 s (C) 3.5 s (D) 2.5 s.

Answer: [C]

$\mu=\frac{1}{2}Li^2$

$\frac{1}{2}=L[i_0(1-e^{-Rt/L})]^2$

$$\mu = \frac{1}{2} L i_0^2 \left(1 - e^{-R/Lt}\right)^2$$

$$\mu' = \frac{\pi}{4}$$

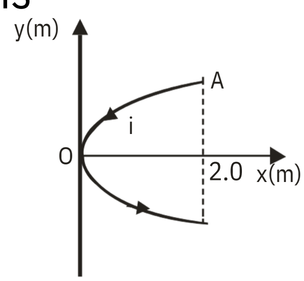
$$1 - e^{-R/Lt} = \frac{1}{2}$$

$$e^{-R/Lt} = \frac{1}{2}$$

$$t = \frac{L \log 2}{R}$$

$$= \frac{10}{2} \times 0.7 = 3.5.$$

38. A conducting wire bent in the form of a parabola $y^2=2x$ carries a current $i=2A$ as shown in figure. This wire is placed in a uniform magnetic field $B=-4\hat{k}$ tesla. The magnetic force on the wire (in Newton) is



(A) $-16\hat{i}$

(B) $32\hat{i}$

(C) $-32\hat{i}$

(D) $16\hat{i}$

Answer: [B]

$$\vec{F}_{AOB} = \vec{F}_{AB} = i(\vec{l} \times \vec{B})$$

Here, $AB = 2\sqrt{2 \times 2} = 4m$

$$\therefore \vec{F}_{AB} = 2\left(4\hat{j} \times -4\hat{k}\right) = -32\hat{i}$$

39. A coil with number of turns N, is made from a wire of length *l*, carrying current I. what will be the magnetic moment of the coil ?

(A) $\frac{l^2 I}{4\pi N^2}$

(B) $\frac{l^2 N I}{4\pi}$

(C) $\frac{l^2 I}{4\pi N}$ (D) $\frac{l^2 I N^2}{4\pi}$

Answer: [C]

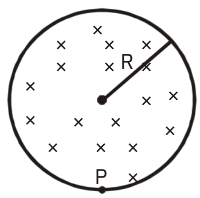
Magnetic moment = $NI(\pi r^2)$

Also $2\pi r N = l$

⇒ $r = \frac{l}{2\pi N}$

Magnetic moment $= \frac{l^2 I}{4\pi N}$.

40. A uniform magnetic field of induction B is confined to a cylindrical region of radius R. The magnetic field is increasing at a constant rate of dB/dt (tesla/s). An electron of charge e is placed at the point P on the periphery of the field experiences an acceleration:



(A) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward left (B) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward right

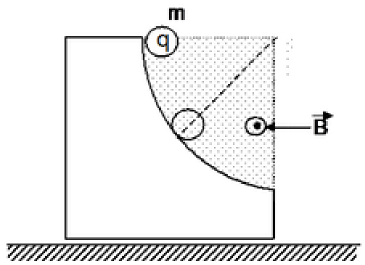
(C) $\frac{eR}{m}\left(\frac{dB}{dt}\right)$ toward left (D) zero

Answer: [A]

Electric field at P $= \frac{1}{2}R\frac{ds}{dt}$ towards right.

Hence, acceleration of electron $= \frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ towards left.

41. In the figure a charged sphere of mass m and charge q starts sliding from rest on a vertical fixed circular track of radius R from the position shown. There exists a uniform and constant horizontal magnetic field of induction B. The maximum force exerted by the track on the sphere is



(A) mg

(B) $3mg - Qb\sqrt{2gR}$

(C) $3mg + qB\sqrt{2gR}$

(D) $mg - Qb\sqrt{2gR}$

Answer:[C]

Fm = qvB, and directed radially outward.

□ $N - mg\sin\theta - qvB = \frac{mv^2}{R}$

⇒ $N = \frac{mv^2}{R} + mg\sin\theta + qvB$

Hence at θ = π/2

⇒ $N_{max} = \frac{2mgR}{R} + mg + qB\sqrt{2gR}$

$= 3mg + qB\sqrt{2gR}$.

42. Electrons at rest are accelerated by a potential of V volt.

These electrons enter the region of space having a uniform, perpendicular magnetic induction field B. The radius of the path of the electrons inside the magnetic field is:

(A) $\frac{1}{B}\sqrt{\frac{mV}{e}}$

(B) $\frac{1}{B}\sqrt{\frac{2mV}{e}}$

(C) $\frac{V}{B}$

(D) $\frac{1}{B}\sqrt{\frac{V}{e}}$

Answer: [B]

The gain in K.E. of the electron after moving through the potential difference

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

⇒ $v = \sqrt{\frac{2eV}{m}}$

$$\Rightarrow r = \frac{mv}{eB} = \frac{1}{B}\sqrt{\frac{2mV}{e}}$$

43. A particle of mass m and charge q moves with a constant velocity v along the positive x direction. It enters a region containing a uniform magnetic field B directed along the negative z direction, extending from x = a to x = b. The minimum value of v required so that the particle can just enter the region x>b is

(A) $\frac{qbB}{m}$

(B) $\frac{q(b-a)B}{m}$

(C) $\frac{qaB}{m}$

(D) $\frac{q(b+a)B}{2m}$

Answer:[B]

Width of the magnetic field region (b - a) ≤ R; where 'R' is its radius of curvature inside magnetic field.

$$\therefore R = \frac{mv}{qB} = (b-a) \qquad \Rightarrow v = \frac{(b-a)qB}{m}$$

44. Two circular coils A and B with their centers lying on the same number of turns and cary equal currents in the same sense. They are separated by a distance, have different diameters but subtend same angle at a point P lying on their common axis. The coil B lies exactly midway between coil A and the point P. The magnetic field at point P due to coils A and B is B1 and B2 respectively

(A) $B_1 > B_2$ (B) $B_1 < B_2$

(C) $\frac{B_1}{B_2} = 2$ (D) $\frac{B_1}{B_2} = \frac{1}{2}$

Answer: [D]

$$B = \frac{\mu_0 N I r^2}{2(r^2 + x^2)^{\frac{3}{2}}} \text{ along } x - \text{axis}$$

$\Rightarrow \quad B = \frac{\mu_0 NI}{2r} \frac{r^3}{(r^2 + x^2)^{3/2}}$

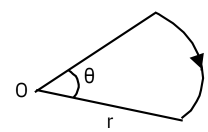
$\Rightarrow$

$B = \frac{\mu_0 NI}{2r} \sin^3\theta$

According to which, the coil with lesser radius is to make more contribution.

$\Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} = \frac{1}{2}$.

45. A wire bent in the form of a sector of radius r subtending an angle θo at centre, as shown in figure is carrying a current i. The magnetic field at O is:



(A) $\frac{\mu_0 i}{2r}\theta$ (B) $\frac{\mu_0 i}{2r}\theta(/180)$ (C) $\frac{\mu_0 i}{2r}(\theta/360)$ (D) zero

Answer: [C]

The magnetic field $B = \frac{\theta}{360^0} B_0$

Where B_0 = magnetic field due to a circular loop

$= \frac{\mu_0 i}{2r}$

$\Rightarrow B = \frac{\theta}{360^0} \frac{\mu_0 i}{2r} = \frac{\mu_0 i}{2r}\left(\frac{\theta}{360}\right)$