MAGNETISM

1. Consider a circular coil of wire carrying constant current I, forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by ϕ_i. The magnetic flux through the area of the circular coil area is given by ϕ_0. Which of the following option is correct ?

(1) $\phi_i = -\phi_0$ (2) $\phi_i = \phi_0$

(3) $\phi_i < \phi_0$ (4) $\phi_i > \phi_0$

2. A loop ABCDEFA of straight edges has six corner points A(0,0,0), B(5,0,0), C(5,5,0), D(0, 5, 0), E(0, 5, 5) and F(0, 0, 5). The magnetic field in this region is $\vec{B} = \left(3\hat{i} + 4\hat{k}\right)T$.

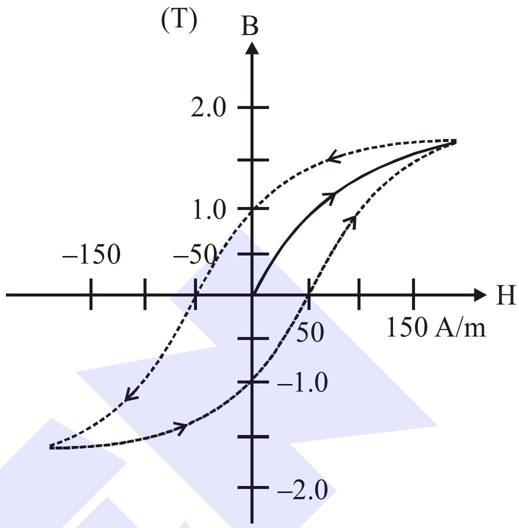
The quantity of flux through the loop ABCDEFA (in Wb) is ______ .

3. A particle of mass m and charge q has an initial velocity $\vec{\upsilon} = \upsilon_0\hat{j}$. If an electric field $\vec{E} = E_0\hat{i}$ and magnetic field $\vec{B} = B_0\hat{i}$ act on the particle, its speed will double after a time:

(1) $\frac{2m\upsilon_0}{qE_0}$ (2) $\frac{3m\upsilon_0}{qE_0}$

(3) $\frac{\sqrt{3}m\upsilon_0}{qE_0}$ (4) $\frac{\sqrt{2}m\upsilon_0}{qE_0}$

4. The figure gives experimentally measured B vs. H variation in a ferromagnetic material. The retentivity, co-ercivity and saturation, respectively, of the material are:



(1) 150 A/m, 1.0 T and 1.5 T

(2) 1.0 T, 50 A/m and 1.5 T

(3) 1.5 T, 50 A/m and 1.0 T

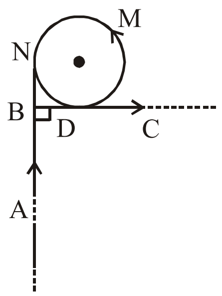
(4) 1.5 T, 50 A/m and 1.0 T

5. Photon with kinetic energy of 1MeV moves from south to north. It gets an acceleration of 10^{12} m/s^2 by an applied magnetic field (west to east). The value of magnetic field : (Rest mass of proton is 1.6×10^{-27} kg) :

(1) 71mT (2) 7.1mT

(3) 0.071mT (4) 0.71mT

6. A very long wire ABDMNDC is shown in figure carrying current I. AB and BC parts are straight, long and at right angle. At D wire forms a circular turn DMND of radius R. AB, BC parts are tangential to circular turn at N and D. Magnetic field at the centre of circle is :



(1) $\frac{\mu_0 I}{2R}$

(2) $\frac{\mu_0 I}{2\pi R}(\pi+1)$

(3) $\frac{\mu_0 I}{2\pi R}\left(\pi+\frac{1}{\sqrt{2}}\right)$

(4) $\frac{\mu_0 I}{2\pi R}\left(\pi-\frac{1}{\sqrt{2}}\right)$

7. A long, straight wire of radius a carries a current distributed uniformly over its cross-section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{3}$ and 2a, respectively from the axis of the wire is :

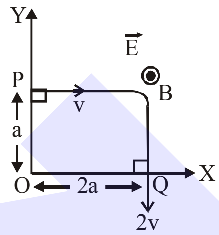
(1) $\frac{2}{3}$

(2) $\frac{3}{2}$

(3) $\frac{1}{2}$

(4) 2

8. A charged particle of mass 'm' and charge 'q' moving under the influence of uniform electric field $E\vec{i}$ and a uniform magnetic field $B\vec{k}$ follows a trajectory from point P to Q as shown in figure. The velocities at P and Q are respectively, $v\vec{i}$ and $-2v\vec{j}$. Then which of the following statements (A, B, C, D) are the correct ? (Trajectory shown is schematic and not to scale) :



(A) $E=\frac{3}{4}\left(\frac{mv^2}{qa}\right)$

(B) Rate of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$

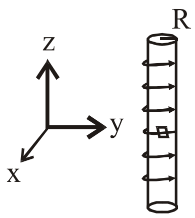
(C) Rate of work done by both the fields at Q is zero

(D) The difference between the magnitude of angular momentum of the particle at P and Q is 2 mav.

(1) (A), (B), (C), (D) (2) (A), (B), (C)

(3) (B), (C), (D) (4) (A), (C), (D)

9. An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current I. The electron gun shoots an electron along the radius of the solenoid with speed v. If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning) :



(1) $\frac{e\mu_0 nIR}{m}$ (2) $\frac{e\mu_0 nIR}{2m}$

(3) $\frac{2e\mu_0 nIR}{m}$ (4) $\frac{e\mu_0 nIR}{4m}$

10. A small circular loop of conducting wire has radius a and carries current I. It is placed in a uniform magnetic field B perpendicular to its plane such that when rotated slightly about its diameter and released, it starts performing simple harmonic motion of time period T. If the mass of the loop is m then :

(1) $T=\sqrt{\frac{\pi m}{2IB}}$ (2) $T=\sqrt{\frac{2\pi m}{IB}}$

(3) $T=\sqrt{\frac{\pi m}{IB}}$ (4) $T=\sqrt{\frac{2m}{IB}}$

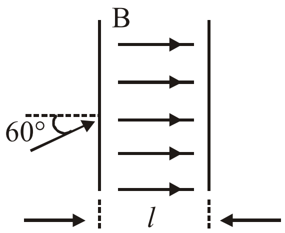
11. A beam of protons with speed $4 \times 10^5\ ms^{-1}$ enters a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. The pitch of the resulting helical path of protons is close to: (Mass of the proton = 1.67×10^{-27} kg, charge of the proton = 1.69×10^{-19} C)

(1) 12 cm (2) 4 cm (3) 5 cm (4) 2 cm

12. Magnetic materials used for making permanent magnets (P) and magnets in a transformer (T) have different properties of the following, which property best matches for the type of magnet required ?

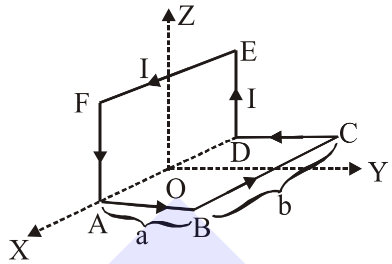
(1) T : Large retentivity, small coercivity
(2) P : Small retentivity, large coercivity
(3) T : Large retentivity, large coercivity
(4) P : Large retentivity, large coercivity

13. The figure shows a region of length 'l' with a uniform magnetic field of 0.3 T in it and a proton entering the region with velocity $4 \times 10^5\ ms^{-1}$ making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, 'l' is close to (mass of proton = 1.67×10^{-27} kg, charge of the proton = 1.6×10^{-19} C)



(1) 0.11 m (2) 0.22 m
(3) 0.44 m (4) 0.88 m

14. A wire carrying current I is bent in the shape ABCDEFA as shown, where rectangle ABCDA and ADEFA are perpendicular to each other. If the sides of the rectangles are of lengths a and b, then the magnitude and direction of magnetic moment of the loop ABCDEFA is :



(1) $\sqrt{2}abI$, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(2) $\sqrt{2}abI$, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

(3) abI, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(4) abI, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

15. A charged particle carrying charge 1 μC is moving with velocity $\left(2\hat{i}+3\hat{j}+4\hat{k}\right)$ ms^{-1}. If an external magnetic field of $\left(5\hat{i}+3\hat{j}-6\hat{k}\right)\times 10^{-3}$ T exists in the region where the particle is moving then the force on the particle is $\vec{F}\times10^{-9}$ N. The vector $\vec{F}$ is :

(1) $-0.30\hat{i}+0.32\hat{j}-0.09\hat{k}$

(2) $-300\hat{i}+320\hat{j}-90\hat{k}$

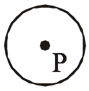
(3) $-30\hat{i}+32\hat{j}-9\hat{k}$

(4) $-3.0\hat{i}+3.2\hat{j}-0.9\hat{k}$

16. Magnitude of magnetic field (in SI units) at the centre of a hexagonal shape coil of side 10 cm, 50 turns and carrying current I (Ampere) in units of $\frac{\mu_0 I}{\pi}$ is :

(1) $250\sqrt{3}$ (2) $5\sqrt{3}$ (3) $500\sqrt{3}$ (4) $50\sqrt{3}$

17. A perfectly dimagnetic sphere has a small spherical cavity at its centre, which is filled with a paramagnetic substance. The whole system is placed in a uniform magnetic field $\vec{B}$. Then the field inside the paramagnetic substance is:



(1) Zero

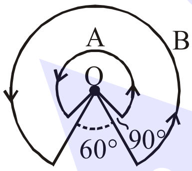
(2) $\vec{B}$

(3) much large than $|\vec{B}|$ but opposite to $\vec{B}$

(4) much large than $|\vec{B}|$ and parallel to $\vec{B}$

18. A galvanometer coil has 500 turns and each turn has an average area of 3×10^{-4} m^2. If a torque of 1.5 Nm is required to keep this coil parallel to magnetic field when a current of 0.5 A is flowing through it, the strength of the field (in T) is _______ .

19. A wire A, bent in the shape of an arc of a circle, carrying a current of 2A and having radius 2 cm and another wire B, also bent in the shape of arc of a circle, carrying a current of 3A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is :



(1) 4 : 6 (2) 6 : 4 (3) 6 :5 (4) 2 : 5

20. A small bar magnet placed with its axis at 30° with an external field of 0.06 T experiences a torque of 0.018 Nm. The minimum work required to rotate it from its stable to unstable equilibrium position is :

(1) 9.2×10^{-3} J (2) 6.4×10^{-2} J

(3) 11.7×10^{-3} J (4) 7.2×10^{-2} J

21. A paramagnetic sample shows a net magnetisation of 6 A/m when it is placed in an external magnetic field of 0.4 T at a temperature of 4 K. When the sample is placed in an external magnetic field of 0.3 T at a temperature of 24 K, then the magnetisation will be :

(1) 4 A/m (2) 0.75 A/m

(3) 2.25 A/m (4) 1 A/m

22. A square loop of side 2a, and carrying current I, is kept in XZ plane with its centre at origin. A long wire carrying the same current I is placed parallel to the z-axis and passing through the point (0, b, 0), (b > > a). The magnitude of the torque on the loop about z-axis is given by:

(1) $\dfrac{2\mu_0 I^2 a^2}{\pi b}$ (2) $\dfrac{\mu_0 I^2 a^3}{2\pi b^2}$

(3) $\dfrac{\mu_0 I^2 a^2}{2\pi b}$ (4) $\dfrac{2\mu_0 I^2 a^3}{\pi b^2}$

23. An iron rod of volume 10^{-3} m^3 and relative permeability 1000 is placed as core in a solenoid with 10 turns/cm. If a current of 0.5 A is passed through the solenoid, then the magnetic moment of the rod will be :

(1) 0.5×10^2 Am^2 (2) 50×10^2 Am^2

(3) 500×10^2 Am^2 (4) 5×10^2 Am^2

24. A particle of charge q and mass m is moving with a velocity $-\upsilon\hat{i}\,(\upsilon \neq 0)$ towards a large screen placed in the Y-Z plane at a distance d. If there is a magnetic field $\vec{B} = B_0\hat{k}$, the minimum value of υ for which the particle will not hit the screen is:

(1) $\dfrac{qdB_0}{2m}$ (2) $\dfrac{qdB_0}{m}$

(3) $\dfrac{2qdB_0}{m}$ (4) $\dfrac{qdB_0}{3m}$

25. An electron is moving along + x direction with a velocity of 6×10^6 ms^{-1}. It enters a region of uniform electric field of 300 V/cm pointing along + y direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the x direction will be:

(1) 5×10^{-3} T, along +z direction

(2) 3×10^{-4} T, along –z direction

(3) 3×10^{-4} T, along +z direction

(4) 5×10^{-3} T, along –z direction

26. A charged particle going around in a circle can be considered to be a current loop. A particle of mass m carrying charge q is moving in a plane with speed v under the influence of magnetic field $\vec{B}$. The magnetic moment of this moving particle :

(1) $-\frac{mv^2\vec{B}}{B^2}$ (2) $-\frac{mv^2\vec{B}}{2\pi B^2}$

(3) $\frac{mv^2\vec{B}}{2B^2}$ (4) $-\frac{mv^2\vec{B}}{2B^2}$

27. A square loop of side 2a and carrying current I is kept in xz plane with its centre at origin. A long wire carrying the same current I is placed parallel to z-axis and passing through point (0, b, 0), (b >> a). The magnitude of torque on the loop about z-ax is will be :

(1) $\frac{2\mu_0 I^2 a^2 b}{\pi(a^2+b^2)}$ (2) $\frac{\mu_0 I^2 a^2 b}{2\pi(a^2+b^2)}$

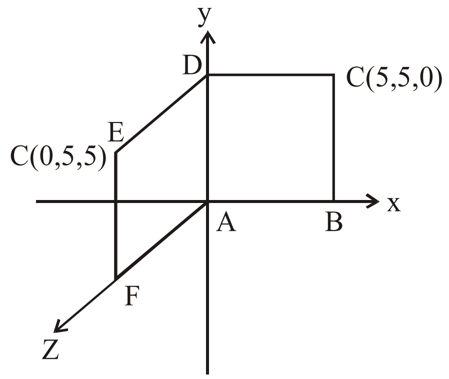
(3) $\frac{\mu_0 I^2 a^2}{2\pi b}$ (4) $\frac{2\mu_0 I^2 a^2}{\pi b}$

SOLUTION

1. NTA Ans. (1)

2. NTA Ans. (175)

Sol.



$\vec{A}_{ABCD} = 25\hat{k}$

$\vec{A}_{ADEF} = 25\hat{i}$

$\vec{A}_{net} = 25\hat{i} + 25\hat{k}$

$\vec{B} = 3\hat{i} + 4\hat{k}$

$\phi = \vec{B}.\vec{A}$

$= 25 \times 3 + 25 \times 4$

$\phi = 175\ W_{b.}$

3. NTA Ans. (3)

Sol. $(2V_0)^2 = v_0^2 + \upsilon_x^2$

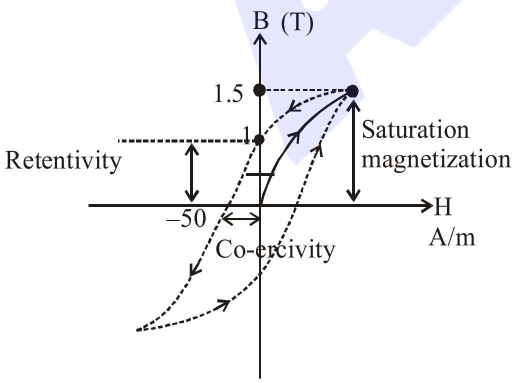
$v_x = \sqrt{3}\, v_0$

$\sqrt{3}\, v_0 = 0 + \dfrac{qE_0}{m} t$

$t = \dfrac{\sqrt{3} v_0 m}{qE_0}$

4. NTA Ans. (2)

Sol.



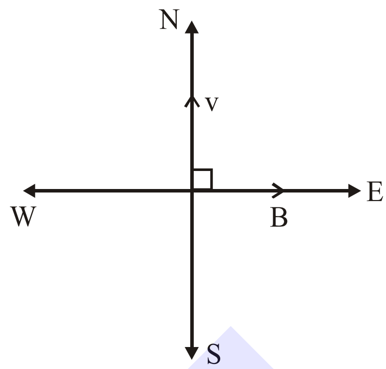
Retentivity = 1.0 T

Co-ercivity = 50 A/m

Saturation = 1.5 T

5. NTA Ans. (4)

Sol. $a = \dfrac{qvB}{m}$



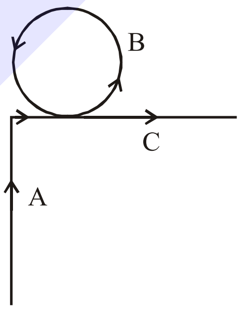
$B = \dfrac{ma}{qv} = \dfrac{ma\sqrt{m}}{\sqrt{2k}}$

$= \dfrac{m^{3/2}a}{e\sqrt{2k}} = \dfrac{(1.6\times10^{-27})^{3/2}\times10^{12}}{1.6\times10^{-19}\sqrt{2\times1\times10^{6}\times1.6\times10^{-19}}}$

$= 0.71\ mT$

6. NTA Ans. (3)

Sol. We say we have 3 parts (A, B, C)



$B = B_A + B_B + B_C$

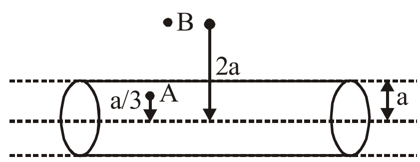
$= \dfrac{\mu_0 I}{4\pi R}(\sin 90° - \sin 45°) \otimes + \dfrac{\mu_0 I}{2R} \odot + \dfrac{\mu_0 I}{4\pi R}(\sin 45° + \sin 90°) \odot$

$= \dfrac{\mu_0 I}{2\pi R}(\sin 45° + \pi)$

$= \dfrac{\mu_0 I}{2\pi R}\left(\pi + \dfrac{1}{\sqrt{2}}\right)$

7. NTA Ans. (1)

Sol.



Let current density be J.

$\therefore$ Applying Ampere's law.

$\oint \vec{B}.d\vec{\ell} = \mu_0 i \Rightarrow B_A\, 2\pi \dfrac{a}{3} = \mu_0 J \pi \left(\dfrac{a}{3}\right)^2$

$\therefore \quad B_A = \dfrac{\mu_0 Ja}{6}$

Similarly, $B_B = \dfrac{\mu_0 Ja}{4}$

$\therefore \quad \dfrac{B_A}{B_B} = \dfrac{\mu_0 Ja \times 4}{\mu_0 J6a} = \dfrac{2}{3}$

8. NTA Ans. (2)

Sol. Option (A)

$W = k_f - k_i$

$qE(2a - 0) = \dfrac{1}{2}m(2V)^2 - \dfrac{1}{2}mV^2$

$qE2a = \dfrac{3}{2}mV^2 \qquad \Rightarrow E = \dfrac{3}{4}\dfrac{mv^2}{qa}$

Option (B)

Rate of work done $P = \vec{F}.\vec{V} = FV\cos\theta = FV$

Power = qEV

Power = $q\left(\dfrac{3}{4}\dfrac{mV^2}{qa}\right)V$

Power = $q\dfrac{3}{4}\dfrac{mV^3}{qa}$

Power = $\dfrac{3}{4}\dfrac{mV^3}{a}$

Option (C)

Angle between electric force and velocity is 90º, hence rate of work done will be zero at Q.

Option (D)

Initial angular momentum L_i = mVa

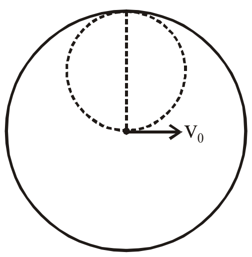
Final angular momentum L_f = m(2V) (2a)

Change in angular momentum $L_f - L_i$ = 3mVa

(Note : angular momentum is calculated about O)

9. NTA Ans. (2)

Sol. Top view of solenoid



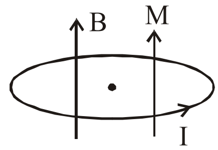
Maximum possible radius of electron = $\dfrac{R}{2}$

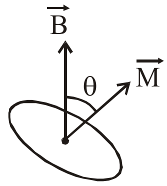
$\therefore \dfrac{R}{2} = \dfrac{mv}{qB} = \dfrac{mv_{max}}{e(\mu_0 ni)} \qquad \Rightarrow v_{max} = \dfrac{R}{2}\dfrac{e\mu_0 ni}{m}$

$\therefore$ Correct answer = 2

10. NTA Ans. (2)

Sol.





$\vec{T} = \vec{M} \times \vec{B} = -MB\sin\theta$

$I\alpha = -MB \sin\theta$

for small θ,

$\alpha = -\dfrac{MB}{I}\theta$

$\omega = \sqrt{\dfrac{MB}{I}} = \sqrt{\dfrac{(i)(\pi R^2)B}{\left(\dfrac{mR^2}{2}\right)}}$

$\omega = \sqrt{\dfrac{2i\pi B}{m}}$

$\therefore = T = \dfrac{2\pi}{\omega} = \sqrt{\dfrac{2\pi m}{iB}}$

$\therefore$ Correct answer (2)

11. Official Ans. by NTA (2)

Sol. Pitch = $\dfrac{2\pi m}{qB}v\cos\theta$

Pitch = $\dfrac{2(3.14)(1.67\times10^{-27})\times4\times10^5\times\cos 60}{(1.69\times10^{-19})(0.3)}$

Pitch = 0.04m = 4 cm

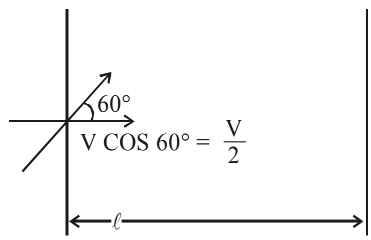
12. Official Ans. by NTA (4)

Sol. As for permanent magnet large retentivity and large coercivity required

13. Official Ans. by NTA (3)

Sol. $T = \dfrac{2\pi m}{qB}$

total time t = 10 T



Kinematics

$\ell = \dfrac{V}{2}t \qquad \Rightarrow \ell = \dfrac{V}{2}10 \times \dfrac{2\pi m}{qB}$

$= 4\times10^5 \times 10 \times \dfrac{3.14\times1.67\times10^{-27}}{1.6\times10^{-19}\times0.3}$

= 0.439

14. Official Ans. by NTA (1)

Sol. M = NIA

N = 1

For ABCD

$$\vec{M}_1 = abI\ \hat{K}.$$

For DEFA

$$\vec{M}_2 = abI\ \hat{j}$$

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

$= ab\ I\ \left(\hat{k}+\hat{j}\right) \quad \Rightarrow = ab\ I\ \sqrt{2}\ \left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

15. Official Ans. by NTA (3)

Sol. $\vec{F} = 9\left(\vec{V}\times\vec{B}\right)$ (Force on charge particle moving in magnetic field)

$\vec{V}\times\vec{B} = (2\hat{i}+3\hat{j}+4\hat{k})\times(5\hat{i}+3\hat{j}-6\hat{k})\times 10^{-3}$

$$= \begin{pmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 4 \\ 5 & 3 & -6 \end{pmatrix} \times 10^{-3}$$

$= \left[\hat{i}[-18-12]-\hat{j}[-12-20]+\hat{k}[6-15]\right]\times 10^{-3}$

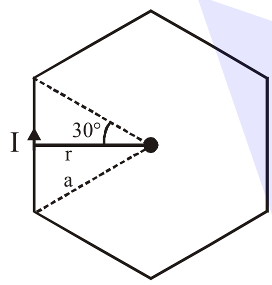
$= \left[\hat{i}[-30]+\hat{j}[32]+\hat{k}[-9]\right]\times 10^{-3}$

$\text{Force} = 10^{-6}[-30\hat{i}+32\hat{j}-9\hat{k}]\times 10^{-3}$

$= 10^{-9}[-30\hat{i}+32\hat{j}-9\hat{k}]$

16. Official Ans. by NTA (3)

Sol.



r = acos30°

$$B = \frac{6\mu_0 I}{4\pi a\cos 30^\circ}\times 2\sin 30^\circ \times 50$$

$$= \frac{\mu_0 I}{\pi}\frac{150}{\sqrt{3}a} = \frac{50\sqrt{3}}{0.1}\frac{\mu_0 I}{\pi}$$

$$= 500\sqrt{3}\frac{\mu_0 I}{\pi}$$

17. Official Ans. by NTA (1)

Sol. A perfect diamagnetic substance will completely expel the magnetic field. Therefore, there will be no magnetic field inside the cavity of sphere. Hence the paramagnetic substance kept inside the cavity will experience no force.

18. Official Ans. by NTA (20)

Sol. $\vec{\tau} = \vec{m}\times\vec{B}$

$\tau = NI\times A\times B$

$105 = 500 \times 3\times10^{-4} \times \frac{1}{2}\times B$

B = 20

19. Official Ans. by NTA (3)

Sol. Given $i_A = 2$, $r_A = 2$ cm, $\theta_A = 2\pi - \frac{\pi}{2} = \frac{3\pi}{2}$

$i_B = 3$, $r_B = 4$ cm, $\theta_B = 2\pi - \frac{\pi}{3} = \frac{5\pi}{3}$

$B = \frac{\mu_0 I\theta}{4\pi R} \quad \Rightarrow \frac{B_A}{B_B} = \frac{I_A}{I_B}\times\frac{\theta_A R_B}{\theta_B R_A} = \frac{6}{5}$

20. Official Ans. by NTA (4)

Sol. Torque on a bar magnet : I = MB sin θ

Here, θ = 30°, I = 0.018 N-m, B = 0.06 T

⇒ 0.018 = M × 0.06 × sin 30°

⇒ 0.018 = M × 0.06 × $\frac{1}{2}$

⇒ M = 0.6 A-m^2

Now v = – MB cos θ

Position of stable equilibrium (θ = 0°) : u_i = – MB

Position of unstable equilibrium (θ = 180°) : u_f = MB

⇒ work done : ΔU

⇒ W = 2MB

⇒ W = 2 × 0.6 × 0.06

⇒ W = 7.2 × 10^{-2} J

option (4) is correct

21. Official Ans. by NTA (2)

Sol. For paramagnetic material

According to curies law

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

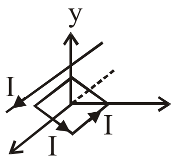
$$\chi \propto \frac{1}{T} \quad \Rightarrow \quad \chi_1 T_1 = \chi_2 T_2$$

$$\Rightarrow \frac{6}{0.4}\times 4 = \frac{I}{0.3}\times 24$$

$$I = \frac{0.3}{0.4} = 0.75\ A/m$$

22. Official Ans. by NTA (1)

Sol.



$\vec{\tau} = \vec{M} \times \vec{B}$

$= 4a^2 I \times \dfrac{\mu_0 I}{2\pi b}$

23. Official Ans. by NTA (4)

Sol. $M = \mu_r NiA$

Here

μ_r = Relative permeability

N = No. of turns

i = Current

A = Aea of cross section

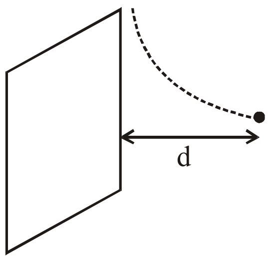
$M = \mu_r NiA = \mu_r n\ell iA$

$M = \mu_r niV = 1000(1000)\ 0.5\ (10^{-3})$

$= 500 = 5 \times 10^2\ Am^2$

24. Official Ans. by NTA (2)

Sol.



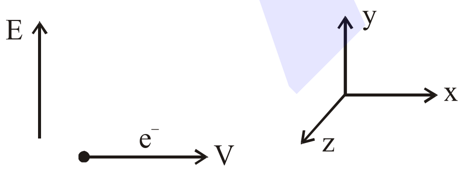
In uniform magnetic field particle moves in a circular path, if the radius of the circular path is 'd', particle will not hit the screen.

$d = \dfrac{mv}{qB_0} \qquad \Rightarrow v = \dfrac{qB_0 d}{m}$

∴ correct option is (2)

25. Official Ans. by NTA (1)

Sol.



$\vec{B}$ must be in +z axis.

$\vec{V} = 6 \times 10^6 \hat{i}$

$\vec{E} = 300\hat{j}$ V/cm = 3×10^4 V/m

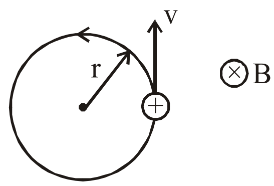
$q\vec{E} + q\vec{V} \times \vec{B} = 0$

E = VB

$B = \dfrac{E}{V} = \dfrac{3 \times 10^4}{6 \times 10^6} = 5 \times 10^{-3} T$

26. Official Ans. by NTA (4)

Sol.



Magnetic moment

M = iA

$M = \left(\dfrac{q}{T}\right) \times \pi r^2 = \dfrac{q\pi r^2}{\left(\dfrac{2\pi r}{v}\right)} = \dfrac{qvr}{2}$

$M = \dfrac{qv}{2} \times \dfrac{vm}{qB}$

$M = \dfrac{mv^2}{2B}$

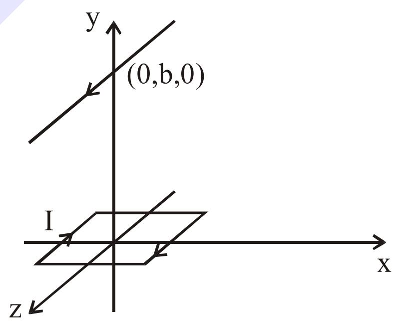
As we can see from the figure, direction of magnetic moment (M) is opposite to magnetic field.

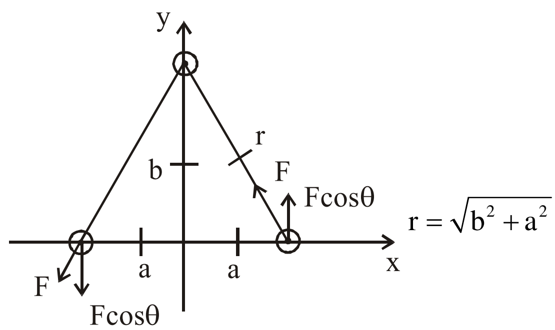
$\vec{M} = -\dfrac{mv^2}{2B}\hat{B}$

$= -\dfrac{mv^2}{2B^2}\vec{B}$

27. Official Ans. by NTA (1)

Sol.





$$F = BI2a = \frac{\mu_0 I}{2\pi r} I \times 2a$$

$$F = \frac{\mu_0 I^2 a}{\pi\sqrt{b^2 + a^2}}$$

$$\tau = F\cos\theta \times 2a$$

$$= \frac{\mu_0 I^2 a}{\pi\sqrt{b^2 + a^2}} \times \frac{b}{\sqrt{b^2 + a^2}} \times 2a$$

$$\tau = \frac{2\mu_0 I^2 a^2 b}{\pi(a^2 + b^2)}$$

If b >> a then $\tau = \frac{2\mu_0 I^2 a^2}{\pi b}$

But among the given options (1) is most appropriate