SCORE JEE (Advanced)
HOME ASSIGNMENT # 02
ELECTROSTATICS
EXERCISE # (O)

1. **Ans. (A)**
Both cuts equal number of electric lines

2. **Ans. (C)**

$$\phi = \frac{Q_{in}}{\epsilon_0} = \int \frac{\rho dV}{\epsilon_0} = \frac{\text{Area under } \rho \text{ v/s x } graph}{\epsilon_0} = \left(\frac{3}{4}\right)$$

3. **Ans. (C)**

4. **Ans. (B)**
τ = PE sinθ as magnitude of P and E is constant torque $\propto$ sinθ

5. **Ans. (C)**

$$\int E.dr = \frac{q_{in}}{\epsilon_0} \Rightarrow E\,(4\pi r^2) = \frac{Q + \int_R^r \frac{\alpha}{r} 4\pi r^2 dr}{\epsilon_0} = \frac{Q + 2\pi\alpha(r^2 - R^2)}{\epsilon_0}$$

$$\Rightarrow E = \frac{\alpha}{2\epsilon_0} + \frac{Q - 2\pi\alpha R^2}{4\pi\epsilon_0 r^2} \Rightarrow Q = 2\pi\alpha R^2$$

6. **Ans. (A)**

7. **Ans. (C)**

8. **Ans. (A, B, D)**

9. **Ans. (A, D)**

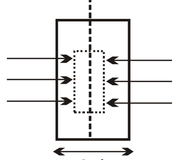
Sol. It we draw a cuboid Gausian surface of lateral cross section A and height h and width 2x where x = distance from central line then E will be pointing as shown (by symmetry)

$\phi_g = \oint E \cdot ds = 2EA = \frac{q_{encl}}{\varepsilon_0}$ (Flux through lateral surface if E = Electric field at distance x

$q_{enclosed} = [\,(\ell)\ (2x)\ (h)\,]\ \rho$

$2E\,A = \frac{q_{enclosed}}{\varepsilon_0} = \frac{2Ax\rho}{\varepsilon_0} = \frac{(2x)(\ell)h\rho}{\varepsilon_0} = \frac{2xA\rho}{\varepsilon_0}$ [as $\ell h = A$]

So $E = -\frac{\rho}{\varepsilon_0}x$



Force = $qE = -\frac{q\rho}{\varepsilon_0}x$

$m\frac{d^2x}{dt^2} = \frac{-q\rho}{\varepsilon_0}x \Rightarrow \omega^2 = \frac{q\rho}{\varepsilon_0 m}$

$\omega = \sqrt{\frac{q\rho}{\varepsilon_0 m}}$; $\nu = \frac{1}{2\pi}\sqrt{\frac{q\rho}{m\varepsilon_0}}$

10. Ans. (A, B, C, D)

Sol. (A) Only equilibrium position changes. Time period remains same T = $2\pi\sqrt{\frac{m}{k}}$.

(B) $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ $\quad\therefore$ v at mean position is same amplitude will be same.

(C) In case - 4 Eaquilibrium position $x_0 = \frac{3mg}{k}$.

11. Ans. (A,B)

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

$\phi_{in} = -ve$ and $\phi_{out} = +ve$

$Q_{net} = \frac{q_{in}}{\varepsilon_0}$

$\phi_1 = 0, \phi_2 = E_0a^3, \phi_3 = E_0a^3,\ \phi_4 = 0, \phi_5 = 0, \phi_6 = 0$

$Q_{net} = \phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 + \phi_6 = 2E_0a^3 \Rightarrow 2E_0a^3 = \frac{q_{in}}{\epsilon_0} \Rightarrow q_{in} = 2\varepsilon_0 E_0 a^3$

12. Ans. (A,C,D)

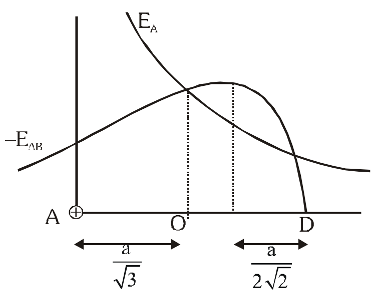
Along X axis, $u_x = u\cos\theta$, $a_x = -\frac{qE}{m}$ $\qquad$ Along Y axis, $u_y = u\sin\theta$, $a_y = -g$

Equations of motion along X and Y axes would be $x = u\cos\theta t - \frac{qE}{2m}t^2$ and $y = u\sin\theta t - \frac{1}{2}gt^2$

Time of flight remains unchanged as vertical motion is not affected by $\vec{E}$. Range of the particle in the present case is always less than $\frac{u^2\sin 2\theta}{g}$ whatever be the value of

E. R = $x_{t=T} = u\cos\theta \times \frac{2u\sin\theta}{g} - \frac{1}{2} \times \frac{qE}{m}\left[\frac{2u\sin\theta}{g}\right]^2 < \frac{u^2\sin 2\theta}{g}$

13. Ans. (B,D)

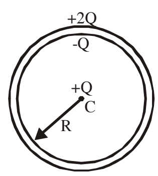


E_A = field due to charge on A; E_{AB} = field due to charges on B and C

14. Ans. (B,C)

15. Ans. (ACD)

–Q charge must be induced on the inner surface of the shell.
Hence +2Q charge appears on its outer surface.



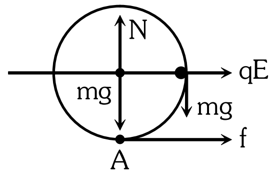
16. Ans. (A,C)

Potential inside $\frac{KQ}{R}\ (r<R)$; Potential out side $\frac{KQ}{r}\ (r>R)$

Paragraph for Question 17 to 19

17. Ans. (C)

At t = 0; qE + f = 2 ma; mgR + qER = $I_A\alpha = I_A\frac{a}{R}$; mg + qE = $(mR^2+mR^2+2mR^2)\frac{a}{R^2}$



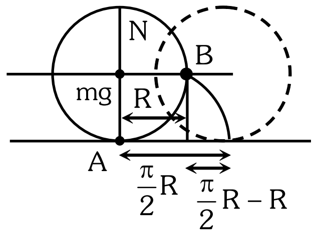
qE = mg, so $a=\frac{g}{2}$ $f = 2ma - qE = 2m\frac{g}{2} - mg = 0$

18. Ans. (B)

Work done by electric field can be calculated by calculating.

Displacement of charge in the direction of field which is (see figure)

$S=\left(\frac{\pi}{2}-1\right)R$

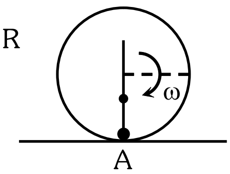


$\widehat{AB}=\frac{\pi}{2}R$

So work done = $qER\left(\frac{\pi}{2}-1\right)=\frac{4}{7}mgR$

19. Ans. (A)

After 90° rotation. Using work energy theorem



$\frac{4}{7}mgR+mgR = \frac{1}{2}I_A\omega^2$; $\sqrt{\frac{11}{7}\frac{g}{R}}=\omega$; $v_{com}=\frac{R}{2}\omega=\sqrt{\frac{11}{7}\frac{g}{R}\frac{R^2}{4}}=\sqrt{\frac{11}{28}Rg}$.

Paragraph for Question 20 & 21

20. Ans. (B)

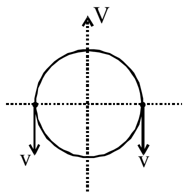
$$y_i=\frac{m\times 0+2m\times\frac{R\sqrt{3}}{2}}{3m}=\frac{R}{\sqrt{3}}=y_f$$

21. Ans. (A)

From conservation of momentum along y-direction

0 = mV –2 mv $\Rightarrow$ V = 2v

Now using energy conservation



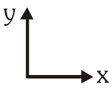
$$\frac{q^2}{4\pi\epsilon_0 R}=\frac{1}{2}m\times 4v^2+\frac{1}{2}mv^2\times 2+\frac{q^2}{4\pi\epsilon_0(2R)} \qquad \Rightarrow v=\sqrt{\frac{q^2}{24\pi\epsilon_0 mR}}$$

$\therefore$ V = 2v

Paragraph for Question 22 to 24

22. Ans. (A)

$\vec{p}=Q\vec{d}=\frac{Q8R}{3\pi}\hat{j}$; $\vec{\tau}=\vec{p}\times\vec{E}=pE\sin\theta\hat{k}$; $|\vec{\tau}|=\frac{8QRE}{3\pi}$



23. Ans. (C)

$\tau_{net}=I\alpha$; $\tau_{electric}-F_rR=I\alpha$

From the equation of translatory motion $f_r = ma \Rightarrow \frac{8QRE}{3\pi}-maR=\frac{mR^2}{2}\frac{a}{R}$

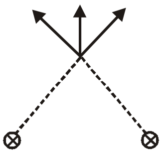
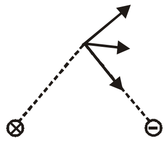
By solving above equation $a=\frac{16QE}{9\pi m}$

24. Ans. (C)

$$F_r = ma = m\left(\frac{16QE}{9\pi m}\right) = \frac{16QE}{9\pi} \quad \because F_r = \mu N = \mu mg \quad \therefore \frac{16QE}{9\pi} = \mu mg \Rightarrow \mu = \frac{16QE}{9\pi mg}$$

25. Ans. (A) → (Q,R) ; (B) → (P,S,T) ; (C) → (P,Q,T) ; (D) → (P,S)

Sol. $v = \frac{kQ}{r}$ & $E = \frac{kQ}{r^2}$ & $U = \frac{kq_1q_2}{r}$

for by symmetry  $\vec{E}$ is || to the axis  $\vec{E}$ is ⊥ as to the axis.

26. Ans. (A) → (P,Q,T) ; (B) → (Q,R,S) ; (C) → (Q,R,S) ; (D) → (R,S)

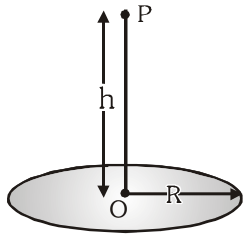
27. Ans. (A) → (R) ; (B) → (S) ; (C) → (P,R,S,T) ; (D) → (S)

Apply Gauss law in all cases

EXERCISE # (S)

1. **Ans. 2**

$V_P = \frac{\sigma}{2\epsilon_0}\left[\sqrt{R^2+h^2}-h\right]$; $V_0 = \frac{\sigma R}{2\epsilon_0}$



To just reach mgh

$= q\,[V_0 - V_P] \Rightarrow \frac{gh\sigma}{4\epsilon_0 g} = \frac{\sigma}{2\epsilon_0}\left[R-\sqrt{R^2+h^2}+h\right]$

$\Rightarrow \frac{h}{2} = R + h - \sqrt{R^2+h^2} \Rightarrow \sqrt{R^2+h^2} = R + \frac{h}{2}$

$\Rightarrow R^2 + h^2 = R^2 + \frac{h^2}{4} + Rh \Rightarrow \frac{3h^2}{4} = Rh \Rightarrow h = \frac{4}{3}R = \left(2\sqrt{\frac{R}{3}}\right)^2 \Rightarrow m = 2$

OR

Check dimensionally $h = \left(2\sqrt{\frac{R}{3}}\right)^m \Rightarrow m = 2$

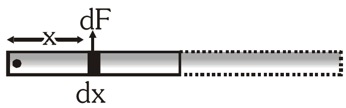
2. **Ans. 5**

$F_x = \left(1\times10^{-6}\right)(5-2x)\times10^6 = 5-2x \quad a_x = \frac{5-2x}{2}, \quad v_x\frac{dv_x}{dx} = \frac{5-2x}{2}$

$\int_0^0 2v_x\,dv_x = \int_0^{X_{max}} (5-2x)dx \Rightarrow 5X_{max} - X_{max}^2 = 0$

3. **Ans. 9**

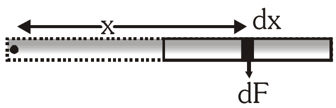
Sol. For $0 < x < \frac{\ell}{2}$, $d\tau_1 = E_0(\lambda dx)x$



$\Rightarrow \tau_1 = \int_0^{\ell/2} E_0\left(15x^2dx\right)x = 15E_0\int_0^{\ell/2} x^3dx = \frac{15E_0}{4}\left(\frac{\ell}{4}\right)^4 = \frac{15E_0\ell^4}{64}$

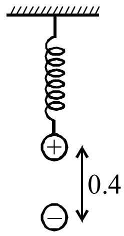
For $\frac{1}{2} < x < \ell$, $d\tau_2 = E_0\,(bx^n dx)x \Rightarrow \tau_2 = \int_{\ell/2}^{\ell} E_0 b x^{n+1}dx = \frac{E_0 b}{n+2}\,\frac{\left(2^{n+2}-1\right)}{2^{n+2}}\ell^{n+2}$

Now According to question $\tau_1 = \tau_2 \Rightarrow \frac{15E_0\ell^4}{64} = \frac{E_0 b\left(2^{n+2}-1\right)\ell^{n+2}}{(n+2)2^{n+2}}$



$\Rightarrow$ 4 = n+2 $\Rightarrow$ n=2 and b=1 Therefore $(a+b)^2 = (2+1)^2 = 9$

4. Ans. 4



$K = 10^4$ N/m; m = 5kg

$$U_i = \frac{-kq^2}{(0.5)}$$

$$U_f = \frac{-kq^2}{0.4} - mg(0.1) + \frac{1}{2}kx^2$$

$$U_i + k_i = U_f + kf_{f^-} \Rightarrow (kq^2)(2) = kq^2(2.5) + mg(0.1) - \frac{1}{2}kx^2$$

$$\frac{1}{2}kx^2 = \frac{kq^2}{2} + mg(0.1)$$

$$\frac{1}{2}(10^2)\times\left(\frac{1}{100}\right) = \frac{(9\times10^9)\times q^2}{2} + \frac{45\times2}{590\times10^9} = q^2$$

$$\Rightarrow q^2 = \frac{5\times2}{10^9} = 10^{-8} \Rightarrow \theta = 100\ \mu C \Rightarrow \alpha\times25 = 100 \Rightarrow \alpha = 4$$

5. Ans. $\frac{kP}{\sqrt{2}\,y^3}(-\hat{i}-2\hat{j})$

6. Ans. 4 py $(y^2 + 4x^2)^{1/2}$

7. Ans. V_{max} = 20 m/s

Sol. $kq^2\left(\frac{1}{r}-\frac{1}{2r}\right) = \frac{1}{2}m(V^2)$

$$\frac{kq^2}{2r} = \frac{1}{2}mV^2$$

$$\frac{kq^2}{r} = \frac{1}{2}m\left(\sqrt{2}V\right)^2 = \frac{1}{2}m\,(V_{max}^2)$$

$$V_{max} = V\sqrt{2} = \left(10\sqrt{2}\right)\sqrt{2} = 20 \text{ m/s.}$$

8. Ans. 168

Let v_1 and v_2 be the speeds of sphere A and B just before collision, then from conservation of energy,

$$0 = \frac{1}{2}mv_1^2\left(1+\frac{2}{3}\right) + \frac{1}{2}(2m)v_2^2\left(1+\frac{2}{5}\right) + \frac{K.Q(-2Q)}{2R}$$

$$0 = \frac{5}{6}mv_1^2 + \frac{7}{5}mv_2^2 - \frac{K.Q^2}{R};\ \frac{5}{6}mv_1^2 + \frac{7}{5}mv_2^2 = \frac{K.Q^2}{R} \quad ...(i)$$

From conservation of angular momentum about any point 'O'

$$0 = mv_1R + \frac{2}{3}mR^2.\left(\frac{v_1}{R}\right) - 2mv_2R - \frac{2}{5}(2m)r^2\left(\frac{v^2}{R}\right);\ v_1 = \frac{42}{25}v_2 \ ...(ii)$$

Solving equation (i) and (ii) $K_B = \frac{25\,KQ^2}{67\,R}$; $K_A = \frac{42\,KQ^2}{67\,R}$

EMI & AC

EXERCISE # (O)

1. **Ans. (B,C)**

Here $\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{5\times10^{-3}\times50\times10^{-6}}}=2000\text{rad/s}$

$\Rightarrow \omega=\frac{1}{\sqrt{LC}}$ so resonance condition $\Rightarrow I=\frac{V}{R}=\frac{20/\sqrt{2}}{6+4}=\sqrt{2}=1.4A$

$\Rightarrow$ Reading of ammeter = 1.4A. $\Rightarrow$ Reading of voltmeter= $4\sqrt{2}$ V = 5.6 V

2. **Ans. (C)**

We have, $Z=\sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}$, thus $\omega\uparrow, Z\downarrow\Rightarrow i$ increases

3. **Ans. (A,C,D)**

$V_1^2=V_R^2+V_L^2$

$V_2=V_C-V_L$

$V^2=V_R^2+\left(V_C-V_L\right)^2$

$PF=\frac{V_R}{V_C-V_L}$

4. **Ans. (B)**

$I=I_0e^{-t/\tau}$, $\tau=L/R$

5. **Ans. (B, D)**

6. **Ans. (B)**

The maximum emf will be at mean position of oscillation $\therefore \frac{mg\ell}{2}(1-\cos\alpha)=\frac{1}{2}\left(\frac{m\ell^2}{3}\right)\omega^2$ and $\varepsilon=\frac{1}{2}B\omega\ell^2$

7. **Ans. (D)**

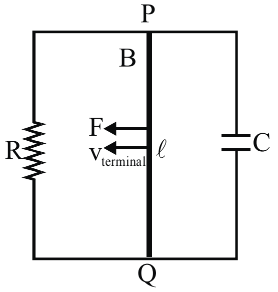
$E=\frac{d\phi}{dt}$, $\phi=B\pi r^2$ and $\frac{dr}{dt}$ = constant so E is constant

8. **Ans. (B)**

$\frac{d\phi}{dt}=\frac{d\phi}{dt}>\frac{d\phi}{dt}$

9. Ans. (B,C)

In steady state



$B\ell V_{terminal} = \dfrac{q_{max}}{C}$ also $iB\ell = F$ & $i = \dfrac{B\ell v_{terminal}}{R}$

10. Ans. (A)

$\phi = \pi r^2 [\cos \omega t\, \hat{j} + \sin \omega t\, (-\hat{i})] . [B_y \hat{j} + B_z \hat{k}]$, $\phi_2 = B_y \pi r^2 \cos \omega t$, $E = \left|\dfrac{d\phi}{dt}\right| = B_y\, \omega \pi r^2 \sin \omega t$

11. Ans. (D)

12. Ans. (B)

13. Ans. (C)

14. Ans. (D)

$V = 2t \Rightarrow L\dfrac{di}{dt} = 2t \Rightarrow 2 \times \dfrac{di}{dt} = 2t \Rightarrow \dfrac{di}{dt} \Rightarrow i = \dfrac{t^2}{2} \Rightarrow i - t$ graph parabola

$U = \dfrac{1}{2} Li^2 = \dfrac{1}{2} \times 2 \times 4 = 4J$ and $\dfrac{dU}{dt} = Li\dfrac{di}{dt} = 2 \times \dfrac{t^2}{2} \times t = t^3 = 1J/s$

Paragraph for Question No. 15 to 17 (3 questions)

15. Ans. (C)

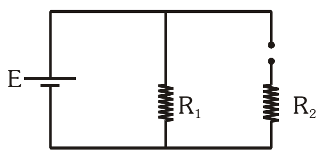
16. Ans. (A)

17. Ans. (B)

Paragraph for Question No. 18 to 20

18. Ans. (B)

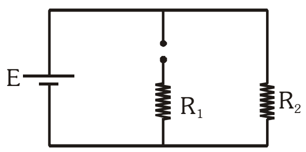
At t = 0



$I_1 = \dfrac{E}{R_1} = \dfrac{25}{5} = 5A$

19. Ans. (A)

At t = ∞



$I_1 = 0$

20. Ans. (C)

$I_2 = \dfrac{E}{R_2} = \dfrac{25}{10} = 2.5\ A$

Paragraph for Question No. 21 & 22

21. Ans. (B)

22. Ans. (C)

Paragraph for Question No. 23 to 25

23. Ans. (D)

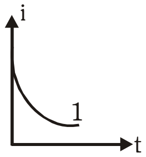
As current is leading the source voltage, so circuit should be capacitive in nature and as phase difference is not $\frac{\pi}{2}$, it must contain resistor also.

24. Ans. (A)

Time delay $=\frac{\phi}{\omega}=\frac{\pi}{400}\Rightarrow\phi=\frac{\pi}{4}$; $\tan^{-1}\left(\frac{1}{R\omega C}\right)=\frac{\pi}{4}\Rightarrow\frac{1}{\omega C}=R$

$$i_0=\frac{v_0}{\sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}}\Rightarrow\sqrt{2}=\frac{100}{\sqrt{R^2+R^2}}\rightarrow R=50\Omega \text{ and } C=\frac{1}{50\times100}=200\mu F$$

25. Ans. (B)



For DC circuit $i=i_0e^{-\frac{t}{RC}}$ and RC = 0.01 sec.

Paragraph for Question No.26 & 27 (2 questions)

26. Ans. (B)

27. Ans. (B)

28. Ans. (A) Q, (B) R (C) S

Sol. (A) $\phi=\tan^{-1}\left(\frac{R}{X_L}\right)=\tan^{-1}\left(\frac{R}{\omega L}\right)=\tan^{-1}\left(\frac{20}{2\pi^2}\right)=\tan^{-1}(1)$

$\phi=\pi/4$

(B) $T=2\pi\sqrt{\frac{\ell}{g}}$; So $T_1\approx 2s$; $T_2\approx 4s$

$\Delta\phi=(\Delta\omega)t=\left(\frac{2\pi}{T_1}-\frac{2\pi}{T_2}\right)t=2\pi\left(\frac{1}{2}-\frac{1}{4}\right)1$

$\Delta\phi=\pi/2$

(C) $\Delta\phi=k\Delta x=\frac{2\pi}{\lambda}\Delta x=\frac{2\pi f}{V}\Delta x=\pi$

$V=\sqrt{\frac{T}{\mu}}=100$ m/s

29. Ans. (A) QR (B) S, (C) S (D) S

For (A) : emf = E and final current is zero.

For (B) : emf = E and current is increasing.

For (C) : emf = E and final current is E/R.

For (D): emf = E and current is increasing.

EXERCISE # (S)

1. **Ans. 8**

$\phi = \vec{B}.\vec{A}$; $\varepsilon = -\frac{d\phi}{dt} = K\pi a^2$; $i = \frac{\varepsilon}{R} = \frac{Ka^2}{R}$ and at t = T ; B = 0 $\Rightarrow 0 = C - KT \Rightarrow T = \frac{C}{K}$

$q = i \times T = \frac{\pi a^2 C}{R} = 8C$

2. **Ans. 4**

$P = \frac{\pi t\sigma}{2}\alpha^2\int_0^a r^3 dr = \frac{\pi t\sigma a^4}{8}\alpha^2$

3. **Ans. L = 10 μH ,V = 100 μV, M = 5 μH**

4. **Ans. clockwise, BV** $\sqrt{4R^2 - v^2t^2}$

5.. **Ans. 300**

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{2\times 10^{-5}}$

Equation of oscillation of charge on capacitor is $q = q_0\cos\omega t$

Energy in capacitor = $\frac{q^2}{2C}$ and energy in inductor = $\frac{1}{2}Li^2$

Given : $\frac{1}{2}Li^2 = \frac{1}{3}\frac{q^2}{2C}$; solving $t = \frac{\pi}{300}$ ms $\Rightarrow \alpha = 300$

6. **Ans.** $\frac{E\ R_1}{R_1R_2 + R_2R_3 + R_3R_1}$

7. **Ans. 125 or 1250**

Sol. $\frac{\theta^2}{2C}$ = 160 μJ ... (1)

$\frac{\theta}{C}$ = 16 V ... (2)

from (1) & (2) :

$\frac{\theta}{2} = \frac{160\times 10^{-6}}{16}$

$\Rightarrow$ Q = 20 × 10^{-6} C

$\therefore$ C = $\frac{\theta}{16} = \frac{20}{16}$ μF = 1.25 μF

8. **Ans. 400**

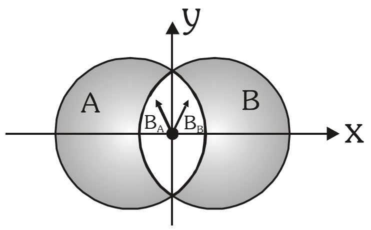
From the given data $\omega L = \frac{1}{\omega C}$. Thus power factor is zero

Power dissipated = $\frac{V^2}{R} = 400W$

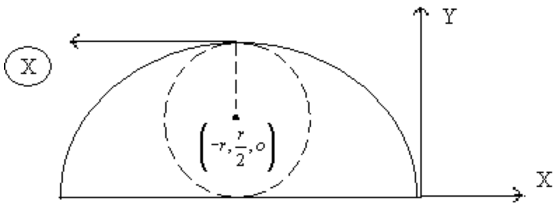
MAGNETIC EFFECT OF CURRENT

EXERCISE # (O)

1. **Ans. (C)**

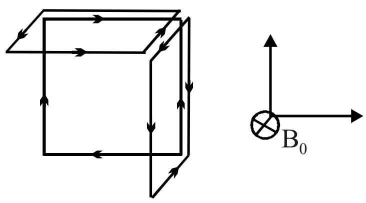


2. **Ans. (B)**



3. **Ans. (D)**

Sol. Imagine 3 loops.



$B = \sqrt{B_0^2 + B_0^2 + B_0^2} = \sqrt{3}\, B_0$ towards F

4. **Ans. (B)**

For ring to be in equilibrium, $\mu mgr \geq Q\dfrac{\pi r^2 R}{2\pi r}.r$

5. **Ans. (A)**

Length PS $= \sqrt{2}\,r$ {r = radius of circular part of loop}

$F_{PS} = i\ell B = i\sqrt{2}\,rB = F$

length PQR = 2 r; $F_{PQR} = \sqrt{2}\,F$

6. **Ans. (C)**

$F = BIL\left(-3\hat{j} + 2\hat{i}\right)$

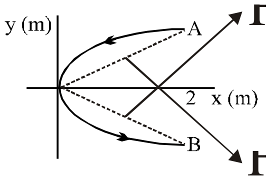
7. Ans. (B)

Since the projection of AB on CD is the same and both carry the same current so each pair experiences the same force.

8. Ans. (B)

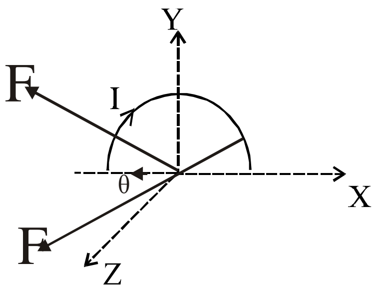
Since momentum is conserved so $r_1 = r_2$

9. Ans. (B)



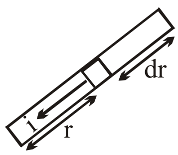
$F\sqrt{2}\hat{i} \Rightarrow \left(2\sqrt{2}\right) \times 2A \times 4\sqrt{2}\hat{i}$

10. Ans. (A)



$2F_m\cos\theta$

11. Ans. (A)



Torque due to magnetic force $|d\vec{\tau}| = \int_0^L (idrB)r = \frac{iL^2B}{2}$

In equilibrium $\frac{iL^2B}{2} = (kx) \times L\sin 30° \text{ or } x = \frac{5iLB}{8k}$

12. Ans. (A)

Paragraph for question nos. 13 to 15

13. Ans. (D)

Geographical north of earth is south pole of the earth's magnetism

14. Ans. (D)

Pitch = $V_{\parallel}$ × time to complete one rotation = $V_{\parallel} \times \frac{2\pi m}{qB}$

Period of rotation = $\frac{2\pi m}{qB}$

15. Ans. (C)

If electron rotates counterclockwise, proton will rotate clockwise if seen from noth pole.

Paragraph for Question No. 16 to 18

16. Ans. (B)

$\tau = K\theta \Rightarrow K = \frac{\tau}{\theta} = \frac{\vec{M} \times \vec{B}}{\theta} = \frac{niAB}{\theta} \Rightarrow K = \frac{250 \times 100 \times 10^{-6} \times 2.1 \times 1.2 \times 10^{-4} \times 0.23}{28} = 5.2 \times 10^{-8}$ Nm/degree

17. Ans. (B)

$$\theta = \frac{\tau}{K} = \frac{niAB \times 2}{5.2 \times 10^{-8}} \simeq 56^\circ$$

18. Ans. (B)

$$I = \frac{niAB'}{\theta K'},\ B' = 3B,\ K' = 3K \Rightarrow \theta = 28^\circ$$

Paragraph for Question No. 19 to 21

19. Ans. (A)

$$F_m = \left[q\left(8\hat{i} - 6\hat{j} + 4\hat{k}\right) \times 10^6\right] \times 0.4\hat{k}$$

$$F_m = 4q \times 10^5\left[-6\hat{i} - 8\hat{j}\right] = 1.6$$

$$q = 4 \times 10^{-7}$$

20. Ans. (B)

Pitch will be around z-axis.

21. Ans. (C)

$$z = 10^6 \times 4 \times 3 \times 2\pi\frac{m}{qB}$$

22. Ans. (A) → (Q) ; (B) → (P) ; (C) → (S) ; (D) → (R)

For (A) : $6 \times \left(\dfrac{\mu_o I}{4\pi\left(x\dfrac{\sqrt{3}}{2}\right)}\right)\left[2 \times \dfrac{1}{2}\right]$

For (B) : $J = \dfrac{I}{8\pi r^2}$; $B = \dfrac{J \times 4\pi x^2}{2\pi x^2}\mu_0 - \dfrac{\mu_0 J\pi x^2}{2\pi(2x)}$

For (C) : $\mu_0\dfrac{I}{2\pi(1.5x)} - 0$

23. Ans. (A)→(P,R), (B)→(S), (C)→(P,Q,R), (D)→(P,R)

24. Ans. (A) →(PQ); (B) →(Q); (C) →(R); (D) →(PST)

For (A) : $\dfrac{V - Blv}{R} = i$; $F = \dfrac{V - Blv}{R} \times Bl$

For (B) : rod is non-conducting so no current

For (C) : No energy dissipated as no resistance

R → Red executes SHM.

F = ilB to left ⇒ f_{ext} to right

F = ilB, $\dfrac{Ldi}{dt} = Blv$ ⇒ not possible to move with constant v.

For (D) : Energy is dissipated during the motion.

Rod will stop.

Work done by F is equal to energy dissipated during the motion.

EXERCISE # (S)

1. **Ans. 0**
2. **Ans.** B_{KLM} do not apply force on charge.

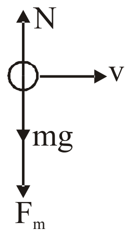
(i) $-\dfrac{\mu_0 I}{4R} q v_0 \hat{k}$ (ii) $F_1 = 2IRB$ $F_2 = 2IRB$, Net force $= F_1 + F_2 = 4IRB\hat{i}$

3. **Ans. 525**

For the rod to remain horizontal, $\tau_{net} = 0$

$$\tau_{air} = \rho\left(\frac{L}{4}\times\frac{L}{2}\right).v.v\frac{3L}{4};\quad \tau_{mag} = \vec{\mu}\times\vec{B} = Ni\left(\frac{L}{4}\right)^2 B \Rightarrow I = \frac{\tau_{air}}{NB\left(\frac{L}{4}\right)^2}$$

4. **Ans.** $N_{max} = 3mg + qB\sqrt{2gR}$



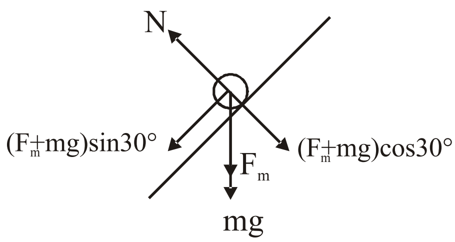
$$\frac{1}{2}mv^2 = mgR$$

$$N = mg + F_m + \frac{mv^2}{R}$$

5. **Ans.** $0.62\ N < F < 0.88\ N$

$F_m = 0.5$

mg = 1



$$N = \frac{3\sqrt{3}}{4} = 1.29$$

$$(F_m + mg)\sin 30° = 0.75$$

$\mu N = 0.129$