JEE ADVANCED-2016

PHYSICS

1. Sol. (C)

Electrostatic energy $= BE_N - BE_O$

$$[[7M_H + 8M_n - M_N] - [8M_H + 7M_n - M_o]] \times C^2$$

$$[-M_H + M_n + M_o - M_N]C^2$$

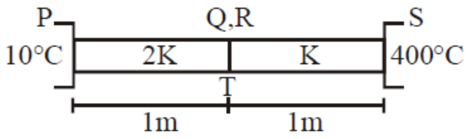
$$= [-1.007825 + 1.008665 + 15.003065 - 15.000109] \times 931.5$$

$$= +3.5359 MeV$$

$$\Delta E = \frac{3}{5} \times \frac{1.44 \times 8 \times 7}{R} - \frac{3}{5} \times \frac{1.44 \times 7 \times 6}{R} = 3.5359$$

$$R = \frac{3 \times 1.44 \times 14}{5 \times 3.5359} = 3.42\ fm$$

2. Sol. (A)



Heat flow from P to Q

$$\frac{dQ}{dt} = \frac{2KA(T-10)}{1}$$

Heat flow from Q to S

$$\frac{dQ}{dt}=\frac{KA(400-T)}{1}$$

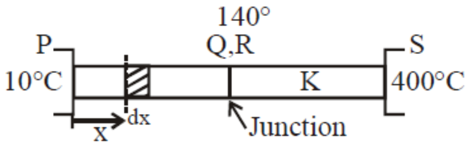
At steady state heat flow is same in whole combination

$$\frac{2KA(T-10)}{1}=KA(400-T)$$

$$2T-20=400-T$$

$$3T=420$$

$$T=140^{\circ}$$



Temp of junction is 140°C

Temp at a distance x from end P

is $T_x=(130x+10^{\circ})$

Change in length dx is dy

$$dy=\alpha dx(T_x-10)$$

$$\int_0^{\Delta y} dy=\int_0^1 \alpha dx(130x+10-10)$$

$$\Delta y=\left[\frac{\alpha x^2}{2}\times 130\right]_0^1$$

$$\Delta y=1.2\times 10^{-5}\times 65$$

$$\Delta y=78.0\times 10^{-5}m=0.78\,\text{mm}$$

3. Sol. (C)

Let the permissible level have activity of $A_{\text{permissible}}$

Thus, initially

$A_0 = 64A_{\text{permissible}}$ [Given]

Let number of days required be t.

$$\therefore \frac{A_0}{2^{t/t_{1/2}}} = A_{\text{permissible}}$$

$$\Rightarrow \frac{64A_{\text{permissible}}}{2^{t/18}} = A_{\text{permissible}}$$

$$\therefore t = 108\,\text{days}$$

4. Sol. (C)

For caliper C_1

$10VSD = 9MSD$

$LC = 1MSD - 1VSD$

$LC = 0.01\text{cm}$

Measured value = Main scale reading + vernier scale reading

$= (2.8 + 7 \times 0.01)\text{cm}$

$= 2.87\text{cm}$

For Caliper C_2

$10VSD = 11MSD$

$LC = 0.01\text{cm}$

Measured value $= \{2.8 + (10-7) \times 0.01\}\text{cm}$

$= 2.83\text{cm}$

5. Sol. (C)

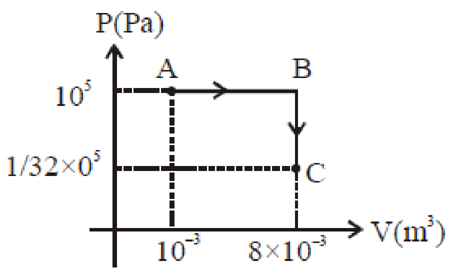
In adiabatic process

$P^3V^5 = \text{constant}$

$\Rightarrow PV^{5/3} = \text{constant}$

$\Rightarrow \gamma = \frac{5}{3} \Rightarrow C_V = \frac{3}{2}R \text{ and } C_P = \frac{5}{2}R$

In another process



$\Delta Q = nC_P\Delta T + nC_V\Delta T$

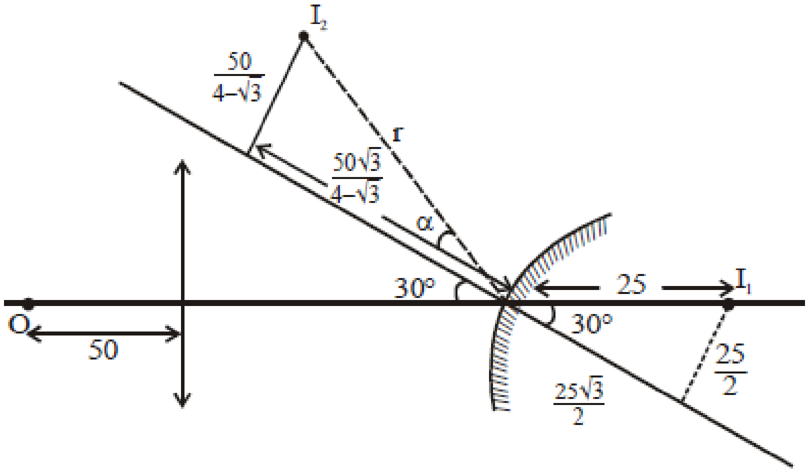
$= \frac{5}{2}nR(T_B - T_A) + \frac{3}{2}nR(T_C - T_B)$

$\Delta Q = \frac{5}{2}(P_BV_B - P_AV_A) + \frac{3}{2}(P_CV_C - P_BV_B)$

Putting values

$\Delta Q = 587.5\,J \approx 588J$

6. Sol. (A)



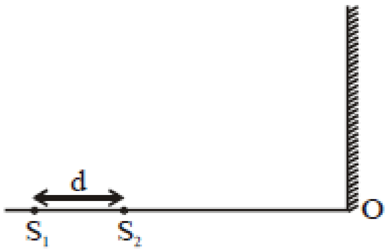
$$\text{For lens } V = \frac{(-50)(30)}{-50+30} = 75$$

$$\text{For mirror } V = \frac{\left(\frac{25\sqrt{3}}{2}\right)(50)}{\frac{25\sqrt{3}}{2} - 50} = \frac{-50\sqrt{3}}{4-\sqrt{3}}$$

$$m = -\frac{v}{u} = \frac{h_2}{h_1} \Rightarrow h_2 = -\left(\frac{\frac{-50\sqrt{3}}{4-\sqrt{3}}}{\frac{25\sqrt{3}}{2}}\right) \cdot \frac{25}{2}$$

$$h_2 = \frac{+50}{4-\sqrt{3}}$$

7. Sol. (B, C)



Path difference at point $O = d = .6003 \text{ mm} = 600300 \text{ nm}$

$$= \frac{2001}{2}(600\text{nm}) = 1000\lambda + \frac{\lambda}{2}$$

$\Rightarrow$ minima form at point O

Line S_1S_2 and screen are $\perp$ to each other so fringe pattern is circular (semi-circular because only half of screen is available)

8. Sol. (A, B, D)

	T	Absolute error
1	0.52	–0.04
2	0.56	00
3	0.57	+0.01
4	0.54	–0.02
5	0.59	+0.03
	$T_{avg} = 0.556$ $= 0.56$	

Avg. absolute error $= \frac{.04 + 00 + .01 + .02 + .03}{5} = .02$

$$\Rightarrow \frac{\Delta T}{T} \times 100\% = \frac{.02}{.56} \times 100\% \approx 3.57\%(B)$$

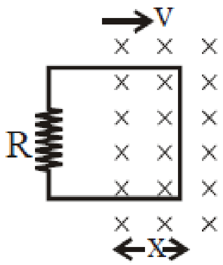
$$\Rightarrow \frac{\Delta r}{r} \times 100\% = \frac{1}{10} \times 100 = 10\%(A)$$

$$\text{also}\ \frac{\Delta g}{g}=\frac{\triangle R+\Delta r}{R-r}+\frac{2\triangle T}{T}$$

$$\frac{\Delta g}{g}100\%=\frac{1+1}{50}\times 100\%+2(3.57)\%$$

$$\approx 11\%(D)$$

9. Sol. (C, D)



When loop was entering $(x<L)$

$$\phi = BLx$$

$$e=\frac{d\phi}{dt}=-\frac{dx}{dt}$$

$$|e| = BLV$$

$$i=\frac{e}{R}=\frac{BLV}{R}(ACW)$$

$$F=i\ell B(\text{Left direction})=\frac{B^2L^2V}{R}(\text{in left direction})$$

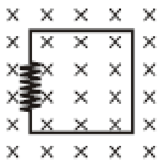
$$\Rightarrow a = \frac{F}{m} = -\frac{B^2L^2V}{mR}\, a = V\frac{dV}{dx}$$

$$V\frac{dV}{dx} = -\frac{B^2L^2V}{mR} \Rightarrow \int_{V_0}^{V} dV = \frac{B^2L^2}{mR}\int_0^X dx$$

$$\Rightarrow V = V_0 - \frac{B^2L^2}{mR}x(\text{straight line of negative slope for } x < L)$$

$$I = \frac{BL}{R}V \Rightarrow \left(I \text{ vs } x \text{ will also be straight line of negative slope for } x < L\right)$$

$L \le x \le 3L$

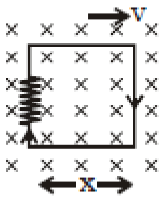


$$\frac{d\phi}{dt} = 0$$

$e = 0\, i = 0$

$F = 0$

$x > 4L$



$e = B\ell v$

Force also will be in left direction.

$$i = \frac{BLV}{R}(\text{clockwise})\, a = -\frac{B^2L^2V}{mR} = V\frac{dV}{dx}$$

$$F = \frac{B^2L^2V}{R} \quad \int_L^x -\frac{B^2L^2}{mR}dx = \int_{V_i}^{V_f} dV$$

$$\Rightarrow -\frac{B^2L^2}{mR}(x-L)=V_f-V_i$$

$$V_f=V_i-\frac{B^2L^2}{mR}(x-L)\text{(straight line of negative slope)}$$

$$I=\frac{BLV}{R}\to\text{(Clockwise) (straight line of negative slope)}$$

10. Sol. (A)

$$K_{\max}=\frac{hc}{\lambda_{Ph}}-\phi$$

kinetic energy of e^- reaching the anode will be

$$K=\frac{hc}{\lambda_{Ph}}-\phi+eV$$

Now

$$\lambda_e=\frac{h}{\sqrt{2mK}}=\frac{h}{\sqrt{2m\left(\frac{hc}{\lambda_{Ph}}-\phi eV\right)}}$$

If $ev>>\phi$

$$\lambda_e=\frac{h}{\sqrt{2m\left(\frac{hc}{\lambda_{Ph}}+eV\right)}}$$

If $V_f=4V_i$

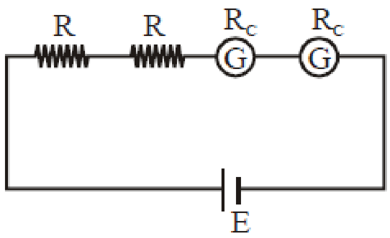
$$(\lambda_e)_f\simeq\frac{(\lambda_e)_i}{2}$$

11. Sol. (A,D)

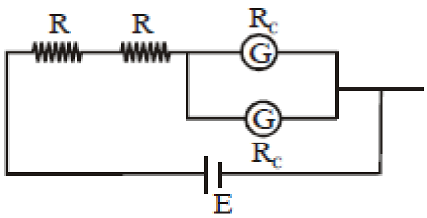
Magnitude of angular momentum of the assembly about its centre of

$$\text{mass} = \frac{ma^2}{2}\omega + \frac{4m(2a)^2}{2}\omega = \frac{17ma^2}{2}\omega$$

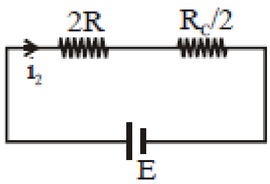
12. Sol. (A,C)



$$i = \frac{E}{2R+2R_C} \qquad V_{g_1} iR_C = \frac{ER}{2(R+R_C)} = \frac{ER_C}{2R+2R_C} \quad \ldots(\text{i})$$



$\Rightarrow$



$$i_2 = \frac{E}{2R + \frac{R_C}{2}} \qquad V_{g_2} = \frac{i_2}{2} \times R_C$$

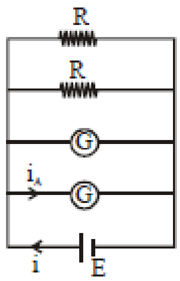
$$= \frac{1}{2}\left(\frac{E}{2R + \frac{R_C}{2}}\right) \times R_C$$

$$V_{g_2} = \frac{ER_C}{4R+R_C} \qquad \ldots(2)$$

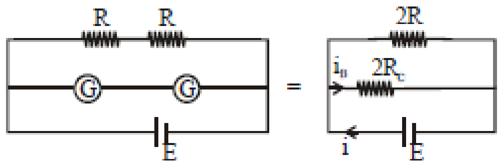
$$\text{Since } R_C < \frac{R}{2} \quad (2R_C < R)$$

$2R + 2R_C < 3R$

$V_{g_1} < V_{g_2}$



$\Rightarrow i_A = \dfrac{E}{R_C}$



here

$$i = \frac{E(2R+2R_C)}{2R.2R_C} = \frac{E(R+R_C)}{2RR_C}$$

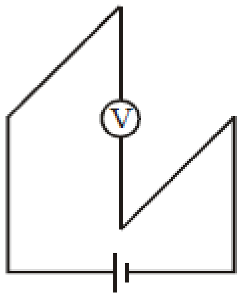
$$i_B = \frac{2R}{2R+2R_C} \times \frac{E(R+R_C)}{2RR_C} = \frac{E}{2R_C}$$

$i_A > i_B$

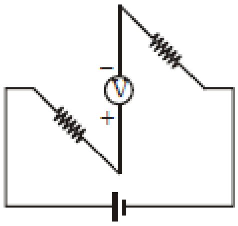
13. Sol. (A,B,C,D)

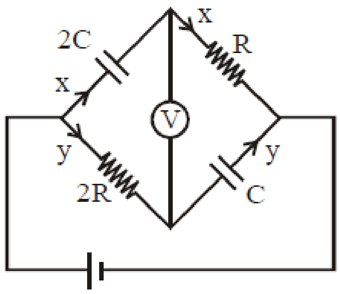
(A) At $t = 0$, capacitor acts as short-circuit

$\therefore$



At $t \to \infty$, capacitor acts as open circuit & no current flows through voltmeter.

$\therefore$ 

(B) 

$q_x = 2CV\left(1 - e^{-t/2CR}\right) \quad X = \frac{V}{R}e^{-t/2CR}$

$q_y = CV\left(1 - e^{-t/2CR}\right) \quad y = \frac{V}{2R}e^{-t/2CR}$

$\Delta V = -y2R + \frac{q_x}{2C}$

$= V\left[1 - 2e^{-t/2CR}\right] = 0$

(C) $\tau = 1\sec$

So by $i = i_0 e^{-t/\tau}$ current at $t = 1\sec \text{is} = i_0/e$

(D) After long time no current flows since both capacitor & voltmeter does not allow.

14. Sol. (A,B,D)

$$T_i = 2\pi\sqrt{\frac{M}{K}}, T_f = 2\pi\sqrt{\frac{M+m}{K}}$$

case (i):

$$M(A\omega) = (M+m)V$$

$\therefore$ Velocity decreases at equilibrium position.

By energy conservation

$$A_f = A_i\sqrt{\frac{M}{M+m}}$$

case (ii) :

No energy loss, amplitude remains same

At equilibrium (x_0) velocity $= A\omega$.

In both cases ω decreases so velocity decreases in both cases

15. Sol. (D)

Force on block along slot $= m\omega^2 r = ma = m\left(\frac{vdv}{dr}\right)$

$$\int_0^V vdv = \int_{R/2}^{r} \omega^2 rdr$$

$$\frac{v^2}{2} = \frac{\omega^2}{2}\left(r^2 - \frac{R^2}{4}\right) \Rightarrow v = \omega\sqrt{r^2 - \frac{R^2}{4}} = \frac{dr}{dt}$$

$$\Rightarrow \int_{R/4}^{r} \frac{dr}{\sqrt{r^2 - \frac{R^2}{4}}} = \int_0^t \omega dt$$

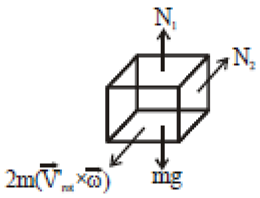
$$\ell n\left(\frac{r + \sqrt{r^2 - \frac{R^2}{4}}}{\frac{R}{2}}\right) - \ell n\left(\frac{R/2 + \sqrt{\frac{R^2}{4} - \frac{R^2}{4}}}{\frac{R}{2}}\right) = \omega t$$

$$\Rightarrow r + \sqrt{r^2 - \frac{R^2}{4}} = \frac{R}{2} e^{\omega t}$$

$$\Rightarrow r^2 - \frac{R^2}{4} = \frac{R^2}{4} e^{2\omega t} + r^2 - 2r\frac{R}{2} e^{\omega t}$$

$$\Rightarrow r = \frac{\frac{R^2}{4} e^{2\omega t} + \frac{R^2}{4}}{\mathrm{Re}\, e^{\omega t}} = \frac{R}{4}\left(e^{\omega t} + e^{-\omega t}\right)$$

16. Sol. (C)



$$\vec{N}_1 = mg\hat{k}$$

$$\vec{N}_2 = 2m\left(V'_{rot} \times \vec{\omega}\right)\hat{j}$$

$$= 2m\left[\frac{\omega R}{4}\left(e^{\omega t} - e^{-\omega t}\right)\right]\omega\hat{j}$$

$$= \frac{1}{2} m\omega^2 R\left(e^{\omega t} - e^{-\omega t}\right)\hat{j}$$

Total reaction on block $= \vec{N}_1 + \vec{N}_2$

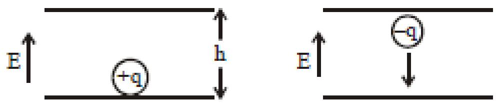
$$= \frac{1}{2} m\omega^2 R\left(e^{\omega t} - e^{-\omega t}\right)\hat{j} + mg\hat{k}$$

17. Sol. (A)

Balls placed on $+ve$ plate become positive charge and move upward due to electric field.

These balls on colliding with negative plate become negatively charged and move opposite to the direction of electric field.

18. Sol. (B)



$$h = \frac{1}{2}\text{at}^2 \quad [\text{as } u = 0]$$

$$\sqrt{\frac{2\text{hm}}{qE}} = \text{time} \Rightarrow \text{time} = \sqrt{\frac{2\text{m}}{q\Delta V}}$$

$$E = \frac{V_0}{h}$$

$$\langle \text{current} \rangle = \frac{\text{charge}}{\text{time}} = \frac{q\sqrt{qV_0}}{2\text{mh}^2}$$

$$q \propto V_0$$

$$< I > \propto V_0^2$$