PART : PHYSICS

1. Radius of electron in ground state of hydrogen is a_0, and radius of electron in He^+ ion in 3rd excited state is a, then $\frac{a_0}{a}$ is

(1) $\frac{1}{2}$ (2) $\frac{1}{4}$ (3) $\frac{1}{16}$ (4) $\frac{1}{8}$

Ans. **(4)**

Sol. $a = a_0 \frac{n^2}{Z}$

$\frac{Z}{n^2} = \frac{a_0}{a}$

$\frac{2}{16} = \frac{a_0}{a}$

$\frac{a_0}{a} = \frac{1}{8}$

2. Electric flux ϕ is related with linear charge density λ and surface charge density σ as $\phi = \alpha\lambda + \beta\sigma$ where α and β are of appropriate dimension then dimension of (β/α) is:

(1) Displacement (2) Area (3) Electric field (4) Velocity

Ans. **(1)**

Sol. $\phi = \alpha\lambda + \beta\sigma$

$\alpha\lambda = \beta\sigma$

$\frac{\beta}{\alpha} = \frac{\lambda}{\sigma} = \frac{Q/L}{Q/L^2} = \frac{Q}{L} \times \frac{L^2}{Q}$

$= L$ (Length)

3. The displacement of a particle as function of time is $x(t) = A\sin(t) + B\cos^2(t) + Ct^2 + D$.

Find dimension of $\left[\frac{ABC}{D}\right]$

(1) L^2 (2) L^2T^{-2} (3) LT^{-2} (4) L^3T

Ans. **(2)**

Sol. Dimension $\rightarrow$ A $\rightarrow$ [L]

Dimension $\rightarrow$ B $\rightarrow$ [L]

$C[T^2] = [L]$

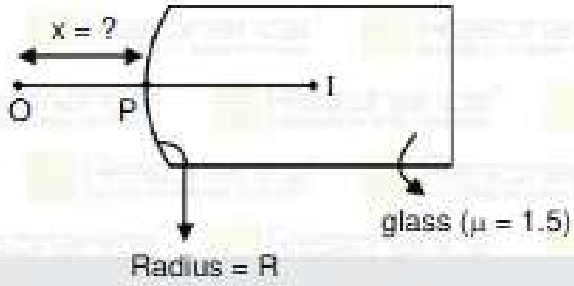
Dimension $\rightarrow$ C $\rightarrow$ $[LT^{-2}]$

Dimension $\rightarrow$ D $\rightarrow$ [L]

So, $\frac{ABC}{D} \Rightarrow \frac{[L][L][LT^{-2}]}{[L]}$

Dimension = $[L^2T^{-2}]$

4. A small point object is placed at some distance from a convex spherical surface of radius of curvature R and refractive index 1.5 as shown in the diagram. It was found that image is formed at equal distance from P. If the distance at which object is placed from point P is x then find x.



(1) 1.5 R (2) 2 R (3) 3 R (4) 5 R

Ans. **(4)**

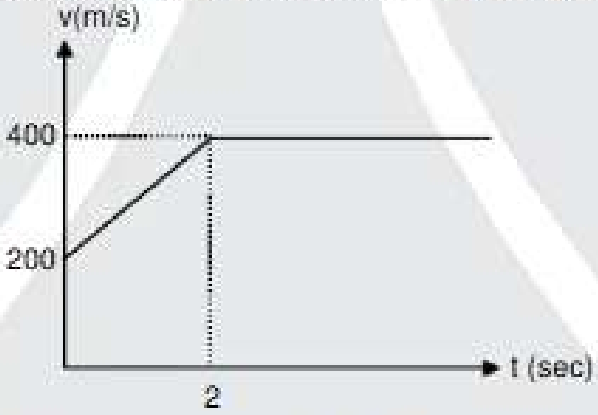
Sol. $\frac{\mu_2}{v} - \frac{\mu_1}{v} = \frac{\mu_2 - \mu_1}{R}$

$\frac{1.5}{v} + \frac{1}{v} = \frac{0.5}{R}$

$= \frac{2.5}{v} = \frac{0.5}{R}$

$v = 5R$

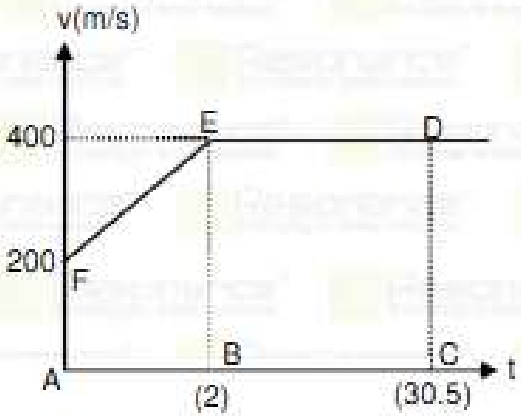
5. For given velocity - time (v-t) graph. Find the distance travelled upto 30.5 sec



(1) 10 Km (2) 11 Km (3) 12 Km (4) 13 Km

Ans. **(3)**

Sol. Distance = $\int_0^{30.5} |v|\,dt$ = Area under v-t graph with +ve sign.



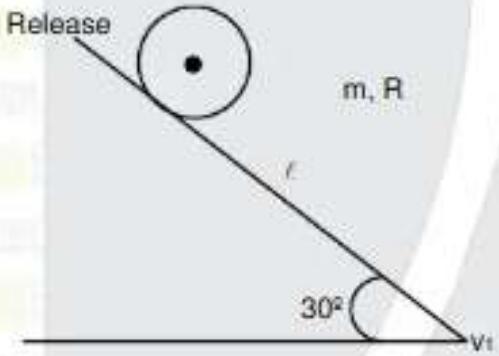
$\Rightarrow$ Area (ABEF) + Area (BCDE)

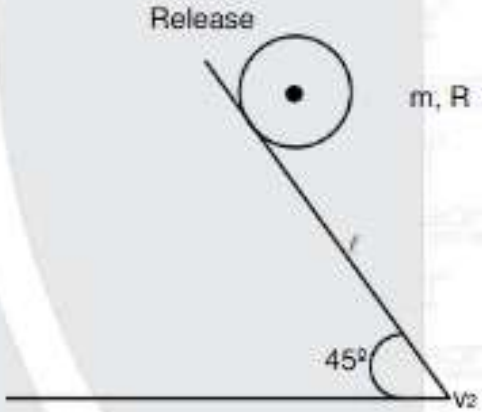
$\Rightarrow \frac{1}{2} \times (200 + 400) \times 2 + 400\,(30.5 - 2)$

$= 600 + \frac{400 \times 2865}{10}$

$= 600 + 11400 = 12000$ m $= 12$ Km

6. Two identical ball of mass m and radius R are released from rest on two inclined planes of length ℓ as shown in diagram. If balls are rolling without sliding then find the ratio of the square of the speed $(v_1^2 : v_2^2)$ with which they will reach on the ground.





(1) $\frac{1}{\sqrt{3}}$ (2) $\frac{1}{\sqrt{2}}$ (3) $\frac{1}{2}$ (4) $\frac{1}{2\sqrt{2}}$

Ans. **(2)**

Sol. H.S

$$a_1 = \frac{g\sin\theta}{1 + \frac{I}{mR^2}}$$

$$a_1 = \frac{g \times \sin 30}{1 + \frac{2/3mR^2}{mR^2}}$$

$$a_1 = \frac{g/2}{5/3} = \frac{3g}{10}$$

$v_1^2 : v_2^2$

$$a_2 = \frac{g\sin 45}{1 + \frac{2/3mR^2}{mR^2}}$$

$$a_2 = \frac{g/\sqrt{5}}{5/3} = \frac{3g}{5\sqrt{2}}$$

$$\frac{v_1^2}{v_2^2} = \frac{2 \times a_1 \times l}{2a_2 \times 1} = \frac{3g/10}{7g/5\sqrt{2}} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}} \Rightarrow \boxed{\frac{v_1^2}{v_2^2} = \frac{1}{\sqrt{2}}}$$

7. **Statement-I** : Hot water moves faster than cold water.
Statement-II : Soap water have higher surface tension than fresh water.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

Ans. **(3)**

Sol. **Statement –I:** Due to increase in temperature Viscosity decreases and K.E. increases so hot water moves faster so it is true
Statement-II : Soap water have Lower surface tension than fresh water.

8. If force $\vec{F} = x^2y\hat{i} + y^2\hat{j}$ is acting on a particle along the line y = x for displacement from A(0, 0) to B(4, 4). Find work done by the force

(1) $\frac{256}{3}$ J (2) 64 J (3) $\frac{64}{3}$ J (4) 256 J

Ans. **(1)**

Sol. Given force $\vec{F} = x^2y\hat{i} + y^2\hat{j}$

Work done $W = \int \vec{F}.d\vec{r} = \int (x^2y\hat{i} + y^2\hat{j}).(dx\hat{i} + dy\hat{j})$

$$= \int_0^4 x^2y\,dx + \int_0^4 y^2\,dy$$

$$= \int_0^4 x^3\,dx + \int_0^4 y^2\,dy = \frac{256}{3}\text{ J}$$

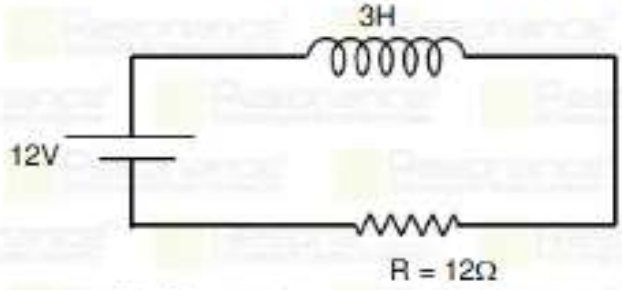
9. Match the column

Column-I	**Column-II**
(P) When volume change is zero	(i) Isochoric process
(Q) When pressure is constant	(ii) Adiabatic process
(C) When no heat is exchanged	(iii) Isobaric process
(D) Work done by the gas is equal to heat given to the gas	(iv) Isothermal process

(1) P → (i) ,Q → (iii), R → (ii), S → (iv)
(2) P → (ii) ,Q → (iii), R → (i), S → (iv)
(3) P → (iii) ,Q → (i), R → (ii), S → (iv)
(4) P → (iv) ,Q → (iii), R → (ii), S → (i)

Ans. **(1)**

10. In the given DC circuit, find the current through R = 12Ω in steady state



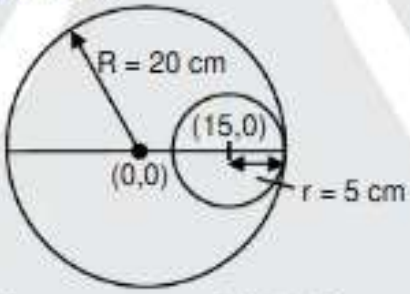
(1) 2A (2) 3A (3) 1A (4) 4A

Ans. **(3)**

Sol. In steady state inductor is short circuited

$$I = \frac{12}{12} = 1\ A$$

11. Find the position of centre of mass of uniform dics of radius 20 cm with respect to previous origin if small disc of radius 5 cm cut from the disc



(1) (–2, 0) (2) (1, 0) (3) (–1, 0) (4) (–5, 0)

Ans. **(3)**

Sol. Let surface mass density = σ

M_1 (mass of disc before removal = $\sigma(\pi R^2)$

M_2 (mass of smaller disc = $\sigma(\pi r^2)$

COM of smaller disc = (15, 0)

COM of disc after removal of disc

$$x_{COM} = \frac{M_1x_1 - M_2x_2}{M_1 - M_2} = \frac{\sigma(\pi R^2 \times 0) - (\sigma\pi r^2)\times 15}{\sigma\pi(R^2 - r^2)}$$

$$x_{COM} = \frac{-15r^2}{R^2 - r^2} = \frac{-15\times 5\times 5}{(20)^2 - (5)^2} = \frac{-15\times 5\times 5}{25\times 15} = -1$$

$y_{COM} = 0$

COM (–1, 0)

12. The ratio of electric force to gravitational force between two particles having charges q_1, q_2 and masses m_1 and m_2 respectively (where symbols have their usual meanings).

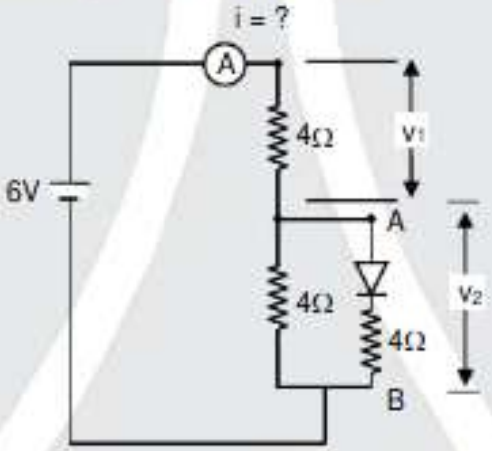
(1) $\frac{4\pi\varepsilon_0 m_1 m_2 G}{q_1 q_2}$ (2) $\frac{4\pi\varepsilon_0 G m_1 m_2}{q_1 q_2 r^4}$

(3) $\frac{q_1 q_2 r^4}{4\pi\varepsilon_0 G m_1 m_2}$ (4) $\frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$

Ans. **(4)**

Sol. $\frac{F_E}{F_G} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}}{G\frac{m_1 m_2}{r^2}} = \frac{q_1 q_2}{4\pi\varepsilon_0 G m_1 m_2}$

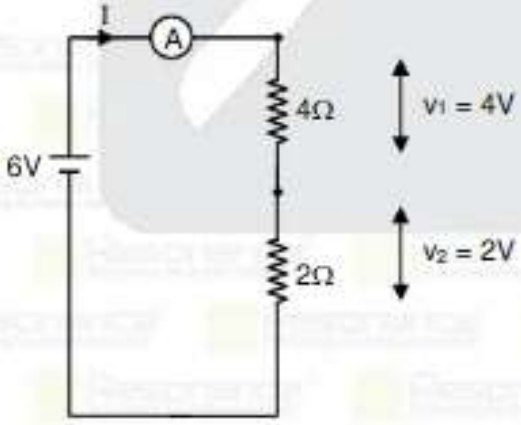
13. Which one is the correct option for given circuit for i, v_1, and v_2



(1) 1 Amp. 2V, 4V (2) 1 Amp. 4V, 2V (3) 2 Amp. 4V, 2V (4) 0.1 Amp. 2V, 4V

Ans. **(2)**

Sol.



$v_4 = \frac{4}{8}\times 6 = \frac{1}{2}\times 6 = 3$ volt

Diode on

$I = \frac{6}{6} = 1$ A

14. Self inductance depends on

(1) only on geometry
(2) only on medium property
(3) Geometry and medium property
(4) value of current through inductor

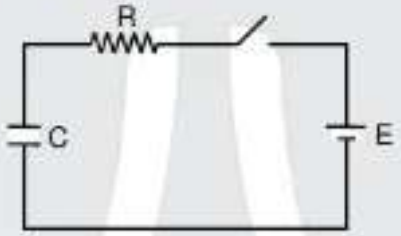
Ans. **(3)**

Sol. Self-inductance = $\mu_r\mu_0$ N_2 Al

Medium Geometry

So, depends on Geometry and medium.

15. The key shown in the circuit is closed at t = 0.
Choose the incorrect option regarding the condition at t = 0



(1) Current in the circuit is zero
(2) Voltage across the capacitor is minimum
(3) Current in the circuit is maximum
(4) Voltage across resistance is maximum

Ans. **(1)**

Sol. $i(t) = \frac{E}{R} e^{-t/RC}$

$q(t) = CE(1 - e^{-t/RC})$

$t = 0, \quad i(t = 0) = \frac{E}{R}$

option (1) $\rightarrow$ incorrect t

$t = 0, q(t = 0) = 0$

$v_C = \frac{q}{c} = 0$ (minimum voltage)

options (ii) $\rightarrow$ correct

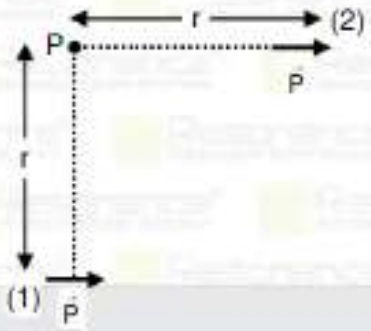
$i(t = 0) = \frac{E}{R}$ (maximum correct)

options (iii) $\rightarrow$ correct

$v_R = iR = \frac{E}{R} \times R = E \ (t = 0)$

option (iv) $\rightarrow$ correct

16. If two dipoles of dipole moment p are placed as shown in figure. Find the net electric force which feels by a point unit charge at point P?



(1) $\frac{2KP}{r^3}$ (2) $\frac{KP}{2r^3}$ (3) $\frac{\sqrt{2}KP}{r^3}$ (4) $\frac{KP}{r^3}$

Ans. **(4)**

Sol. Net electric force at point P

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

$= \frac{kP}{r^3}(-\hat{i}) + \frac{2KP}{r^3}(+\hat{i})$

$\vec{F} = \frac{KP}{r^3}\hat{i}$

17. Adiabatic constant of a gas is $\frac{3}{2}$. If volume of gas initially at 0ºC is reduced to one fourth of the original volume then new temperature is

(1) 0K (2) 273 K (3) 546ºC (4) 546 K

Ans. **(4)**

Sol. $PV^{\gamma} = \text{constant}$

$TV^{\gamma-1} = \text{constant}$

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 273\left(\frac{4V_1}{V_1}\right)^{\frac{3}{2}-1}$

$T_2 = 273 \times 2 = 546\ K$

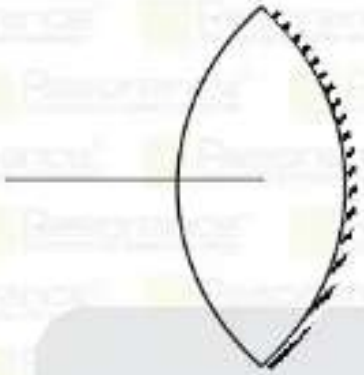
18. Given a convex lens of refractive index μ_2 in a liquid of refractive index μ_1, $\mu_1 < \mu_2$ having radii of curvature R_1, R_2 then R_2 surface a silver polished. Where should an object be placed on the optical axis so that the real and inverted image is formed at the same place

(1) $\frac{(\mu_2+\mu_1)|R_1|}{(\mu_2-\mu_1)}$ (2) $\frac{\mu_1|R_1||R_2|}{\mu_2(|R_1|+|R_2|-\mu_1|R_2|)}$

(3) $\frac{\mu_1|R_1||R_2|}{\mu_2(2|R_1|+|R_2|-\mu_1|R_2|)}$ (4) $\frac{\mu_1|R_1|-|R_2|}{\mu_2(|R_1|+|R_2|-\mu_1\sqrt{|R_1|-|R_2|})}$

Ans. **(2)**

Sol.



$$\frac{1}{f_C} = -\frac{-2}{f_L} + \frac{1}{f_M}$$

$$\Rightarrow \frac{1}{f_C} = -2\left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right) - \frac{2}{R}$$

$$\Rightarrow \frac{1}{f_C} = \frac{-2(\mu_2 - \mu_1)}{\mu_1}\frac{(R_1 + R_2)}{R_1R_2} - \frac{2}{R_2} \times \frac{\mu_1 R_1}{\mu_1 R_1}$$

$$= \frac{-\mu_1 R_1 R_2}{(\mu_2 - \mu_1)(R_1 + R_2) + \mu_1 R_1} = \frac{-\mu_1 R_1 R_2}{\mu_2(R_1 + R_2) - \mu_1 R_2}$$

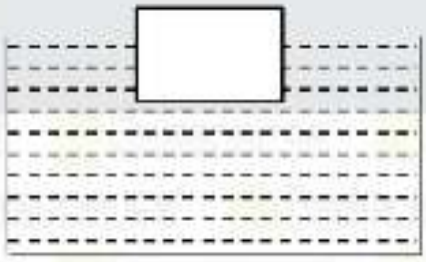
19. What is the dimensional formula of torsional constant ?

(1) $[ML^2T^{-2}]$ (2) $[ML^3T^2]$ (3) $[M^2LT^2]$ (4) $[M^2L^1T^2]$

Ans. **(1)**

Sol. $[ML^2T^{-2}]$

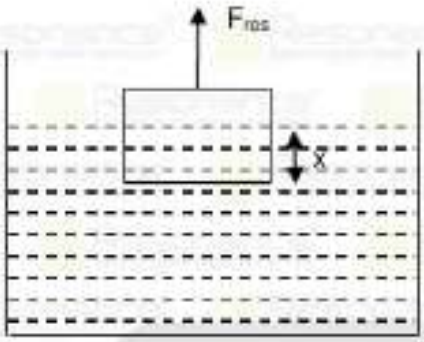
20. Find the time period of a cube of side length 10 cm and mass 10 gm oscillating in water (Density of water $= 10^3$ kg/m^3 and g = 10 m/s^2)



(1) $\frac{\pi}{25}$ second (2) $\frac{\pi}{50}$ seconds (3) $\frac{\pi}{100}$ second (4) $\frac{2\pi}{25}$ second

Ans. **(2)**

Sol.



$F_{res} = -(V_{in})\rho_w g = -(Ax)\rho_w g$

$-(Ax)\rho_w g = ma$

$-Ax\rho_w g = m(\omega^2 x)$

$$\omega^2 = -\frac{A\rho_\omega}{m} g$$

$$\Rightarrow \omega = \frac{2\pi}{T} = \sqrt{\frac{A\rho_w g}{m}}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{m}{A\rho_w g}}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{10\times10^{-3}}{10\times10\times10^{-4}\times10^{-3}\times10}}$$

$$T = 2\pi\sqrt{\frac{10^{-3}}{10}} = 2\pi\sqrt{10^{-4}}$$

$$= 2\pi \times 10^{-2}$$