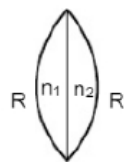


PHYSICS – JEE ADVANCED PAPER – 2

SECTION – 1

1. Consider two plane convex lens of same radius of curvature and refractive index n_1 and n_2 respectively. Now consider two cases:



Case – I: When $n_1 = n_2 = n$, then equivalent focal length of lens is f_0

Case – II: When $n_1 = n$, $n_2 = n + \Delta n$, then equivalent focal length of lens is $f = f_0 + \Delta f_0$

Then correct options are:

- (a) If $\Delta n/n > 0$, then $\Delta f_0/f_0 < 0$
- (b) $|\Delta f_0/f_0| < |\Delta n/n|$
- (c) If $n = 1.5$, $\Delta n = 10^{-3}$ and $f_0 = 20$ cm then $|\Delta f_0| = 0.02$ cm
- (d) If $\Delta n/n < 0$, then $\Delta f_0/f_0 > 0$

Solution:

$$\frac{1}{f_1} = (n-1) \left(\frac{1}{f} \right) \Rightarrow \frac{1}{f_0} = \frac{2(n-1)}{R} \quad \dots (1)$$

$$\frac{1}{f_2} = (n + \Delta n - 1) \left(\frac{1}{R} - \frac{1}{\infty} \right)$$

$$\begin{aligned} \frac{1}{f + \Delta f_0} &= \left(\frac{n-1}{R} \right) + (n + \Delta n - 1) \left(\frac{1}{f} \right) \\ &= \frac{2n + \Delta n - 2}{R} \quad \dots (2) \end{aligned}$$

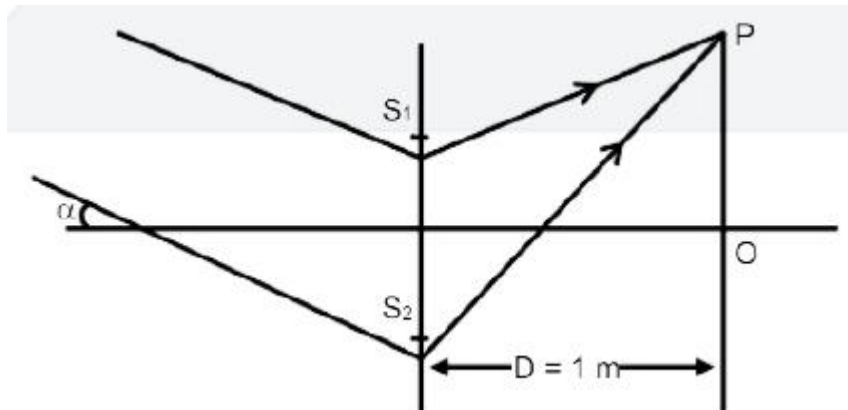
$$\left(\frac{f_0 + \Delta f_0}{f_0} \right) = \frac{(2n-1)/R}{(2n + \Delta n - 2)/R}$$

$$\frac{1 + \Delta f_0/f_0}{1} = \frac{2(n-1)}{2n + \Delta n - 2}$$

$$\Delta f_0 = -2 \times 10^{-2}$$

A, C

2. In YDSE monochromatic light of wavelength 600 nm incident of slits as shown in figure.



If $S_1S_2 = 3\text{mm}$, $OP = 11\text{ mm}$ then

- (a) If $\alpha = \frac{0.36}{\pi}$ degree then destructive interfaces at point P.
 (b) If $\alpha = \frac{0.36}{\pi}$ degree then constructive interfaces at point O.
 (c) If $\alpha = 0$ then constructive interfaces at O
 (d) Fringe width depends on α

Solution:

$$d = 3\text{mm}$$

$$OP = 11\text{ mm}$$

$$\Delta x = d \sin \alpha + d \sin \theta$$

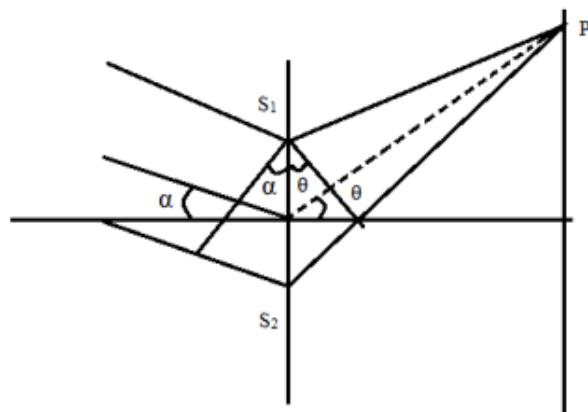
$$= d\alpha + \frac{dy}{D}$$

$$(A) \Delta x = 3 \times 10^{-3} \times \frac{.36}{\pi} \times \frac{\pi}{180} + \frac{3 \times 11 \times 10^{-6}}{1} = 3900$$

$$3900 = (2n-1) \frac{\lambda}{2} \Rightarrow n = 7$$

Dest

$$(B) \Delta x = 3\text{mm} \times \frac{.36}{\pi} \times \frac{\pi}{180} = 600\text{nm}$$

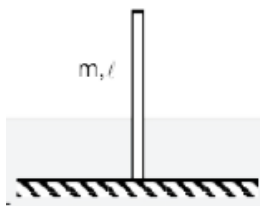


$$600nm = n 600nm$$

$$\Rightarrow n = 1 \text{ const}$$

$$(C) \alpha = 0 \quad \Delta x = 0 \quad \therefore \text{const}$$

3. A uniform rigid rod of mass m & length l is released from vertical position on rough surface with sufficient friction for lower end not to slip as shown in figure. When rod makes angle 60° with vertical then find correct alternative/s



$$(a) \alpha = \frac{2g}{\ell}$$

$$(b) \omega = \sqrt{\frac{3g}{2\ell}}$$

$$(c) N = \frac{mg}{16}$$

$$(d) a_{\text{radial}} = \frac{3g}{4}$$

Solution:

$$\Delta K + \Delta U = 0$$

$$\frac{1}{2} I_0 \omega^2 = -\Delta U$$

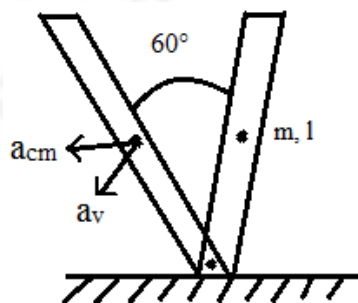
$$\frac{1}{2} \frac{ml^2}{3} \omega^2 = -\left(-mg \frac{L}{4}\right)$$

$$\omega = \sqrt{\frac{3g}{u}}$$

$$a_{\text{radial}} = \frac{\omega^2 \ell}{2} = \frac{3g}{u} \times \frac{\ell}{2} = \frac{3g}{4}$$

$$\tau = I_0 \alpha$$

$$\alpha = \frac{mg \frac{l}{2} \sin 60}{I^2} = \frac{3\sqrt{3}g}{4l}$$



$$a_v = \left(\alpha \frac{l}{2} \right) \sin 60^\circ + \omega^2 \frac{l}{2} \cos 60^\circ$$

$$= \frac{3\sqrt{3}g}{8} \frac{\sqrt{3}}{2} + \frac{3g}{8}$$

$$mg - N = ma_v$$

$$N = \frac{mg}{16}$$

4. Monoatomic gas A having 5 mole is mixed with diatomic gas B having 1 mole in container of volume V_0 . Now the volume of mixture is compressed to $\frac{V_0}{4}$ by adiabatic process. Initial pressure and temperature of gas mixture is P_0 and T_0 . [given $2^{3.2} = 9.2$]

Choose correct option:

- (a) $\gamma_{mix} = 1.6$ (b) Final pressure is between $9P_0$ and $10P_0$
 (c) $|W.D| = 13RT_0$ (d) Average Translational kinetic energy

Solution:

$$V_{mix} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 C_{V_1} + n_2 C_{V_2}} = \frac{8}{5}$$

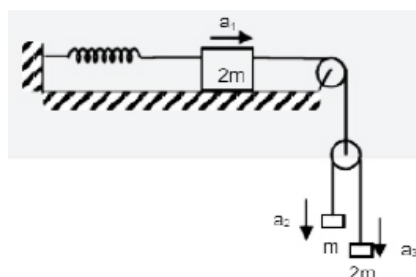
$$W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1}$$

$$P_0 V_0^{8/5} = P_2 \left(\frac{V_0}{9} \right)^{8/5}$$

$$P_2 = 9.2 P_0$$

$$\omega = \frac{\left(P_0 V_0 - 9.2 P_0 \frac{V_0}{4} \right)}{3/5} = -13RT_0$$

5. The given arrangement is released from rest when spring is in natural length. Maximum extension in spring during the motion is x_0 . a_1 , a_2 and a_3 are accelerations of the blocks. Make the correct options



(a) $a_2 - a_1 = a_1 - a_3$

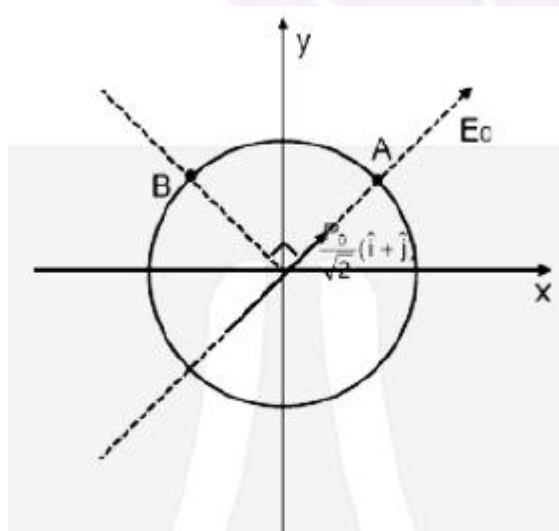
(b) $x_0 = \frac{4mg}{3k}$

(c) Velocity of 2m connected to spring when elongation is $\frac{x_0}{2}$ is $v = \frac{x_0}{2} \sqrt{\frac{3k}{14m}}$

(d) Acceleration a_1 at $\frac{x_0}{4}$ is $\frac{3kx_0}{42m}$

Solution:

6. A dipole of Dipole moment $p = \frac{P_0}{\sqrt{2}}(\hat{i} + \hat{j})$ is placed at origin. Now a uniform external electric field at magnitude E_0 is applied along direction of dipole. Two points A and B are lying on a equipotential surface of radius R centered at origin. A is along axial position of dipole and B is along equatorial position. There correct option are:



(a) Net electric field at point A is $3E_0$

(b) Net electric field at point B is Zero

(c) Radius of equatorial surface $R = \left(\frac{kp_0}{E_0} \right)^{1/3}$ (d) Radius of equatorial surface $R = \left(\frac{\sqrt{2}kp_0}{E_0} \right)^{1/3}$

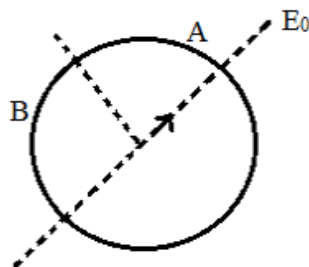
Solution:

$$P = \frac{P_0}{\sqrt{2}}(x+1)$$

$$\frac{KP_0}{r^3} = E_0$$

$$(E_A)_{net} = \frac{2KP_0}{r^3} + E_0 = 3E_0$$

$$(E_B)_{net} = 0$$



7. A free hydrogen atom after absorbing a photon of wavelength λ_a gets excited from state $n = 1$ to $n = 4$. Immediately after electron jumps to $n = m$ state by emitting a photon of wavelength λ_e . Let change in momentum of atom due to the absorption and the emission are ΔP_a and Δp_e respectively. If $\lambda_a / \lambda_e = 1/5$. Which of the following is correct
- (a) $m = 2$
 - (b) $\Delta P_a / P_e = 1/2$
 - (c) $\lambda_e = 418 \text{ nm}$
 - (d) Ratio of K.E. of electron in the state $n = m$ to $n = 1$ is $1/4$.

Solution:

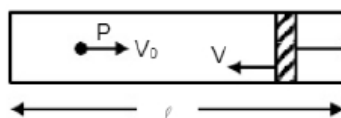
$$\frac{\lambda_a}{\lambda_e} = \frac{E_4 - E_1}{E_4 - E_m} = \frac{\left(1 - \frac{1}{16}\right)}{\left(\frac{1}{m^2} - \frac{1}{16}\right)} = \frac{1}{5}$$

$$\Rightarrow m = 2$$

$$\lambda_e = \frac{12400 \times 4}{13.6} = 3647$$

$$\frac{K_2}{K_1} = \frac{1^2}{2^2} = \frac{1}{4}$$

8. In a cylinder a heavy piston is moving with speed v as shown diagram and gas is filled inside it. A gas molecule is moving with speed v_0 towards moving piston. Then which of the following is correct (Assume $v \ll v_0$ and collision is elastic)



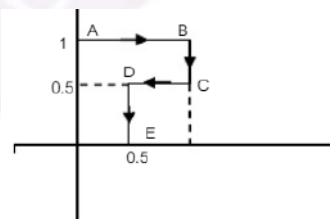
- (a) change in speed after collision is $2V$
 (b) change in speed after collision is $2v_0 \frac{\Delta \ell}{\ell}$
 (c) rate of collision is $\frac{V}{\ell}$
 (d) When piston is at $\frac{\ell}{2}$ its kinetic energy will be four times

Solution:

Change in speed is $(2V + V_0 - V_0) = 2V$

SECTION – 2

9. If $f = \alpha y \hat{i} + 2\alpha x \hat{j}$ calculate the work done if a particle moves along path as shown in diagram.



Solution:

$$d\omega = \alpha y dx + 2\alpha x dx$$

$$\omega_{A \rightarrow B} = \int \alpha y dx = \alpha \int_0^1 dx = \alpha$$

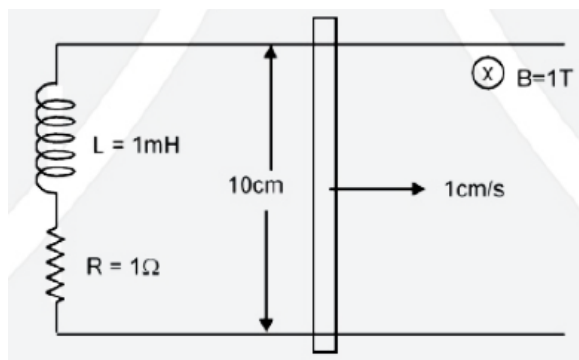
$$\omega_{B \rightarrow C} = 2\alpha \int_1^{0.5} dy = -\alpha$$

$$\omega_{C \rightarrow D} = \int_1^{0.5} \alpha y dx = -\frac{\alpha}{4}$$

$$\omega_{D \rightarrow E} = 2 \times \alpha \int_{0.5}^0 x dy = -\frac{\alpha}{2}$$

$$\omega = -3/4$$

10. In a given circuit inductor of $L = 1\text{mH}$ and resistance $R = 1\Omega$ are connected in series to ends of two parallel conducting rods as shown. Now a rod of length 10 cm is moved with constant velocity of 1 cm/s in magnetic field $B = 1\text{ T}$. If rod starts moving at $t = 0$ then current in circuit after 1 millisecond is $x \times 10^{-3}\text{ A}$. Then value of x is: (given $e^{-1} = 0.37$)



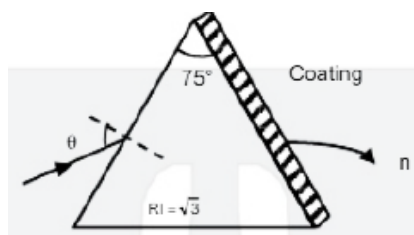
Solution:

$$e = (V \times B) dl = 10^{-3} v df$$

$$i = 10^{-3} (1 - e^{-1})$$

$$i = 0.63\text{ mA}$$

11. A prism is shown in the figure with prism angle 75° and refractive index $\sqrt{3}$. A light ray incidents on a surface at incident angle θ . Other face is coated with a medium of refractive index n . For $\theta \leq 60^\circ$ ray suffers total internal reflection find value of n^2 .



Solution:

$$\sin \theta = \frac{n}{\sqrt{3}}$$

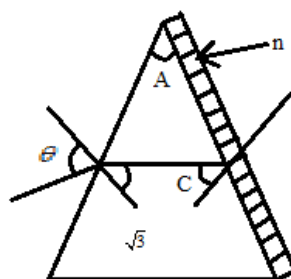
$$\sin \theta = \sqrt{3} \sin(75 - C)$$

$$@ \theta = 60^\circ$$

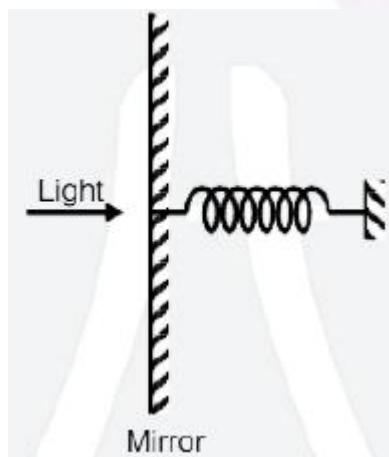
$$\sin 60 = \sqrt{3} \sin(75 - C)$$

$$C = (45^\circ)$$

$$\frac{n}{\sqrt{3}} = \frac{1}{\sqrt{2}} \quad n = \frac{\sqrt{3}}{\sqrt{2}} \quad n^2 = 1.5$$



12. Perfectly reflecting mirror of mass M mounted on a spring constitute a spring mass system of angular frequency Ω such that $\frac{4\pi M \Omega}{h} = 10^{24} m^{-2}$ where h is plank constant. N photons of wavelength $\lambda = 8\pi \times 10^{-6} m$ strikes the mirror simultaneously at normal incidence such that the mirror gets displaced by $1 \mu m$. If the value of N is $x \times 10^{12}$, then find the value of x .



Solution:

Photons are reflected

$$\therefore MV = \frac{2Nh}{\lambda} \quad \text{mean}$$

$$V_{\text{mean}} = \omega A \quad A = 1 \text{ min}$$

$$N = \frac{m\omega(10^{-6})\lambda}{2h}$$

$$N = \frac{4\pi M \omega}{h} \times 10^{-12}$$

$$\therefore X = 1$$

13. A particle is projected with speed v_0 at an angle θ ($\theta \neq 90^\circ$) with horizontal and it bounces at same angle with horizontal. If average velocity of journey is $0.8 v_0$ where v_0 is average velocity of first projectile then α is.

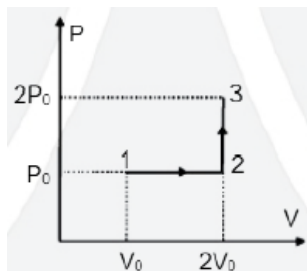


14.

Match the column

A sample of monoatomic gas undergoes different thermodynamic process. Q = Heat given to the gas, W = Work done by the gas, U = Change in internal energy of the gas.

15. The sample of monoatomic gas undergoes a process as represented by $P - V$ graph (if $P_0 V_0 = 1/3 RT_0$) then



$$(P) W_{1 \rightarrow 2} = 1/3 RT_0 \quad (Q) Q_{1 \rightarrow 2 \rightarrow 3} = 11/6 RT_0 \quad (R) U_{1 \rightarrow 2} = RT_0/2 \quad (S) W_{1 \rightarrow 2 \rightarrow 3} = 1/3 RT_0$$

PHYSICS – JEE ADVANCED PAPER – 2

Which of the following options are correct

- (a) P, Q, R, S are correct
(b) Only P, Q are correct
(c) Only R, S are correct
(d) Only P, R, S correct

SOLUTION:

$$W_{1-2} = P_0 V_0 = \frac{1}{3} RT_0$$

$$Q_{2 \rightarrow 3} = n C_V \Delta T = \frac{f}{2} 2V_0 P_0 = RT_0$$

$$Q_{1 \rightarrow 2} = n C_P \Delta T = \frac{5}{6} RT_0$$

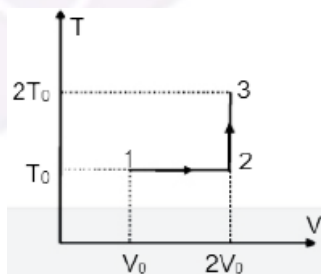
$$W = \frac{1}{3} RT_0$$

$$U_{1-2} = n C_V \Delta T$$

$$= n \frac{3}{2} RT_0$$

$$= \frac{RT_0}{2}$$

16. A sample of monoatomic gas undergoes a process as represented by T – V graph (if $P_0 V_0 = \frac{1}{3} RT_0$) then



(P) $W_{1 \rightarrow 2} = \frac{1}{3} RT_0 \ln 2$

(Q) $Q_{1 \rightarrow 2 \rightarrow 3} = \frac{RT_0}{6} (2 \ln(2) + 3)$

(R) $U_{1 \rightarrow 2} = 0$

(S) $W_{1 \rightarrow 2 \rightarrow 3} = \frac{RT_0}{3} \ln 2$

Which of the following option are correct:

- (a) P, Q are incorrect
(b) R, S are incorrect
(c) P, Q, S are incorrect
(d) none of these

Solution:

$$\omega_{1-2} = n R T_0 \ln 2$$

$$Q_{1-2-3} = Q_{12} + Q_{23}$$

$$= d\omega_{12} + dU_{2-3}$$

$$= \frac{RT_0}{3} \ln 2 + n \frac{f}{2} RT_0$$

$$= \frac{RT_0}{3} \ln 2 + \frac{1}{3} \frac{3}{2} RT_0$$

$$\omega_{1-2-3} = \frac{1}{3} R_0 T_0 \ln 2$$

17. Length of string of a musical instrument is varied from L_0 to $2L_0$ in 4 different cases. Wire is made of different materials of mass per unit length μ , 2μ , 3μ , 4μ respectively. For first case (string – 1) length is L_0 , Tension is T_0 then fundamental frequency is f_0 , for second case length of the string is $\frac{3L_0}{2}$ (3rd Harmonic), for third case length of the string is $\frac{5L_0}{4}$ (5th Harmonic) and for the fourth case length of the string is $\frac{7L_0}{4}$ (14th harmonic). If frequency of all is same then tension in strings in terms of T_0 will be:

- | | |
|----------------|----------------------------|
| (a) String – 1 | (P) T_0 |
| (b) String – 2 | (Q) $\frac{T_0}{\sqrt{2}}$ |
| (c) String – 3 | (R) $\frac{T_0}{2}$ |
| (d) String – 4 | (S) $\frac{T_0}{16}$ |
| | (T) $\frac{3T_0}{16}$ |

Solution:

$$(1) \quad f_1 = \frac{1}{2L_0} \sqrt{\frac{T_0}{\mu}}$$

$$(2) \quad L = \frac{3L_0}{2}$$

$$f_2 = \frac{3}{2 \frac{3L_0}{2}} \sqrt{\frac{T_2}{2\mu}}$$

$$T_2 = \frac{T_0}{2}$$

$$(3) \quad L = \frac{5L_0}{4}$$

$$T_3 = \frac{T_0}{16}$$

$$(4) \text{ Similarly } T_4 = \frac{T_0}{16}$$

SECTION – 3

18. The free length of all four string is varied from L_0 to $2L_0$. Find the maximum fundamental frequency of 1, 2, 3, 4 in terms of f_0 (tension is same in all strings)

(a) String – 1 (P) 1

(b) String – 2 (Q) $\frac{1}{2}$

(c) String – 3 (R) $\frac{1}{\sqrt{2}}$

(d) String – 4 (S) $\frac{1}{\sqrt{3}}$

(T) $\frac{1}{16}$

(U) $\frac{3}{16}$

Solution:

$$(1) \quad f_1 = \frac{1}{2L_0} \sqrt{\frac{T_0}{\mu}}$$

$$(2) \quad f_2 = \frac{1}{L_0} \sqrt{\frac{T_2}{2\mu}} = \frac{f_0}{\sqrt{2}}$$

$$f_3 = \frac{1}{L_0} \sqrt{\frac{T_2}{3\mu}} = \frac{f_0}{\sqrt{3}}$$

$$f_4 = \frac{1}{L_0} \sqrt{\frac{T_2}{4\mu}} = \frac{f_0}{2}$$

