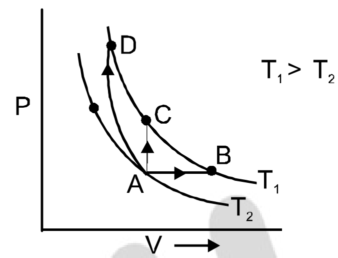
JEE Main 2020 Paper

Date : 5th September 2020

Time : 09 : 00 am - 12 : 00 pm

Subject : Physics

1. Three different processes that can occur in an ideal monoatomic gas are shown in the P vs V diagram. The paths are labelled as $A \rightarrow B$, $A \rightarrow C$ and $A \rightarrow D$. The change in internal energies during these process are taken as E_{AB}, E_{AC} and E_{AD} and the workdone as W_{AB}, W_{AC} and W_{AD}. The correct relation between these parameters are :



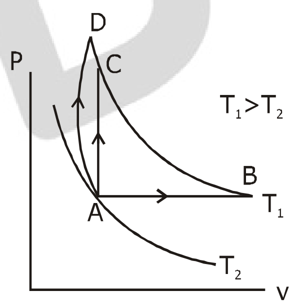
(1) $E_{AB} = E_{AC} = E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} < 0$
(2) $E_{AB} > E_{AC} > E_{AD}$, $W_{AB} < W_{AC} < W_{AD}$
(3) $E_{AB} < E_{AC} < E_{AD}$, $W_{AB} > 0$, $W_{AC} > W_{AD}$
(4) $E_{AB} = E_{AC} = E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} > 0$

Sol. **1 (Bonus)**

$E_{AB} = E_{AC} = E_{AD}$

$\Delta U = \frac{nfR}{2}(T_f - T_i)$

$w_{AB} > 0$ (+) V $\uparrow$
$w_{AC} = 0$ V const.
$w_{AD} < 0$ (–) V$\downarrow$



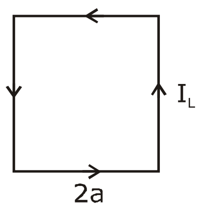
2. With increasing biasing voltage of a photodiode, the photocurrent magnitude :
(1) increases initially and saturates finally
(2) remains constant
(3) increases linearly
(4) increases initially and after attaining certain value, it decreases

Sol. **1**
By theory

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

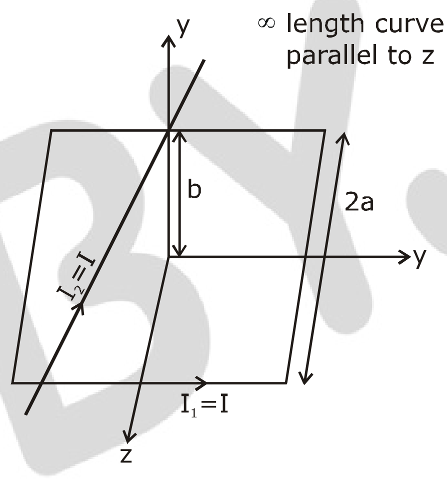
Sol. **3**



$M = I_2\,(2a)^2 = 4a^2 I_2$
(magnetic moment)

$B = \frac{\mu_0 I_2}{2\pi b}$

$\tau = MB \sin\theta$



θ angle between B and M [$\theta = 90°$]

$\tau = 4\,(a^2 I_2)\,\frac{\mu_0 I_1}{2\pi b}$

$\tau = \frac{2\mu_0 I_1 I_2 a^2}{\pi b} = \frac{2\mu_0 I^2 a^2}{\pi b}$

4. Assume that the displacement (s) of air is proportional to the pressure difference (Δp) created by a sound wave. Displacement(s) further depends on the speed of sound (ν), density of air (ρ) and the frequency (f). If $\Delta p \sim 10$Pa, $\nu \sim 300$ m/s , $\rho \sim 1$ kg/m^3 and f$\sim$1000 Hz, then s will be of the order of (take the multiplicative constant to be 1)

(1) 1 mm (2) 10 mm (3) $\frac{1}{10}$ mm (4) $\frac{3}{100}$ mm

Ans. **4**

$$S_0 = \frac{\Delta P}{\beta k} = \frac{\Delta P}{\rho v^2 \frac{\omega}{v}} = \frac{\Delta P}{\rho v \omega} = \frac{\Delta P}{\rho v 2\pi f}$$

$\therefore$ Proportionally constant = 1

$$S_0 = \frac{\Delta P}{\rho v f}$$

$$= \frac{10}{1 \times 300 \times 1000} \text{ m}$$

$$= \frac{10}{300} \text{ mm}$$

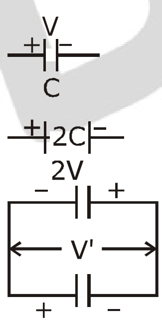
$$= \frac{3}{90}$$

$$\simeq \frac{3}{100} \text{ mm}$$

5. Two capacitors of capacitances C and 2C are charged to potential differences V and 2V, respectively. These are then connected in parallel in such a manner that the positive terminal of one is connected to the negative terminal of the other. The final energy of this configuration is :

(1) zero (2) $\frac{9}{2}$ CV^2 (3) $\frac{25}{6}$ CV^2 (4) $\frac{3}{2}$CV^2

Sol. **4**



$$U_i = \frac{1}{2} Cv^2 + \frac{1}{2} (2C)(2v)^2$$

$$= \frac{9}{2} Cv^2$$

$$q_1 + q_2 = q_1' + q_2'$$

$$-CV + (2C(2V) = (C + 2C)V'$$

$$V' = \frac{3CV}{3C} = V$$

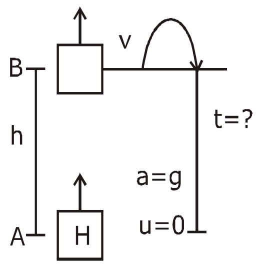
$$U_f = \frac{1}{2} CV^2 + \frac{1}{2} (2C)V^2$$

$$U_f = \frac{3}{2} CV^2$$

6. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to [g is the acceleration due to gravity] :

(1) $t = 3.4\sqrt{\left(\frac{h}{g}\right)}$ (2) $t = \sqrt{\frac{2h}{3g}}$ (3) $t = \frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$ (4) $t = 1.8\sqrt{\frac{h}{g}}$

Sol. **1**



$V_B^2 = 0^2 + 2gh$

$V_B = \sqrt{2gh}$

$-h = (V_B)t - \frac{1}{2}gt^2$

$-h = \sqrt{2gh}\,t - \frac{1}{2}gt^2$

$gt^2 - 2\sqrt{2gh}\,t - 2h = 0$

$$t = \frac{\sqrt{2gh} \pm \sqrt{8gh + 8gh}}{2g} = \frac{2\sqrt{2gh} \pm \sqrt{16gh}}{2g} = \frac{\sqrt{2gh} + 2\sqrt{gh}}{g}$$

$$t = \sqrt{\frac{2h}{g}} + 2\sqrt{\frac{h}{g}} = \sqrt{\frac{h}{g}}\left(\sqrt{2} + 2\right) = 3.4\sqrt{\frac{h}{g}}$$

7. A bullet of mass 5 g, travelling with a speed of 210 m/s, strikes a fixed wooden target. One half of its kinetic energy is converted into heat in the bullet while the other half is converted into heat in the wood. The rise of temperature of the bullet if the specific heat of its material is 0.030 cal/(g – °C) (1 cal = 4.2×10^7 ergs) close to :

(1) 38.4°C (2) 87.5°C (3) 83.3°C (4)119.2°C

Sol. **2**

$\left(\frac{1}{2}m\upsilon^2\right) \times \frac{1}{2} = ms\Delta T$

$\frac{\upsilon^2}{4} = 126 \times \Delta T$

$\upsilon^2 = 4 \times 126 \times \Delta T$

$(210)^2 = 4 \times 126 \times \Delta T$

$210 \times 210 = 4 \times 126 \times \Delta T$

$44100 = 504 \times \Delta T$

$\Delta T = \frac{44100}{504} = 87.5°C$

s = 0.03 cal/gm°C

$= \frac{0.03 \times 4.2J}{10^{-3}kgC}$

= 126 J/kg°C

8. A wheel is rotating freely with an angular speed ω on a shaft. The moment of inertia of the wheel is I and the moment of inertia of the shaft is negligible. Another wheel of moment of inertia 3I initially at rest is suddenly coupled to the same shaft. The resultant fractional loss in the kinetic energy of the system is :

(1) $\frac{3}{4}$ (2) 0 (3) $\frac{5}{6}$ (4) $\frac{1}{4}$

Sol. **1**

$k_i = \frac{1}{2} I\omega^2$

$k_f = \frac{1}{2}(4I)(\omega')^2$

$= 2I\left(\frac{\omega}{4}\right)^2 = \frac{1}{8} I\omega^2$

A.M.C

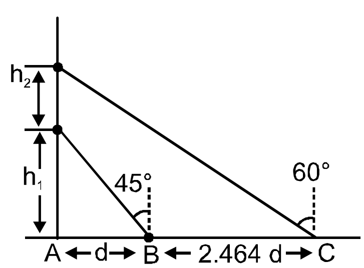
$I\omega = (I+3I)\omega'$

$\omega' = \frac{I\omega}{4I} = \frac{\omega}{4}$

$= \frac{K_i - K_f}{K_i} \Rightarrow \frac{\frac{1}{2}I\omega^2 - \frac{1}{8}I\omega^2}{\frac{1}{2}I\omega^2}$

$\frac{\frac{3}{8}I\omega^2}{\frac{1}{2}I\omega^2} = \frac{3}{4}$

9. A balloon is moving up in air vertically above a point A on the ground. When it is at a height h_1 , a girl standing at a distance d(point B) from A (see figure) sees it at an angle 45° with respect to the vertical. When the balloon climbs up a further height h_2, it is seen at an angle 60° with respect to the vertical if the girl moves further by a distance 2.464 d (point C). Then the height h_2 is (given tan 30° = 0.5774) :



(1) 0.464 d (2) d (3) 0.732 d (4) 1.464 d

Sol. **2**

ΔABD

$\tan 45 = \frac{h_1}{d}$

$\Rightarrow 1 = \frac{h_1}{d} \Rightarrow h_1 = d$

ΔACE

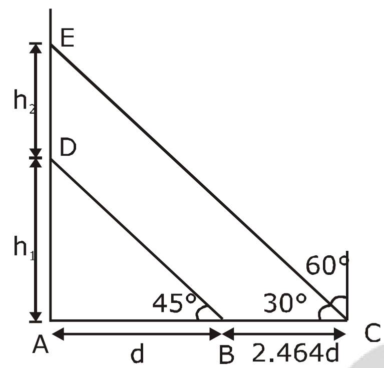
$\tan 30 = \frac{h_1 + h_2}{d + 2.464d}$

$0.5774 = \frac{d + h_2}{3.464d}$

$d + h_2 = 0.5774 \times 3.464 \times d$

$h_2 = 2.0001136d - d$

$h_2 = 2.000d - d = d$



10. An electrical power line, having a total resistance of 2 Ω , delivers 1 kW at 220 V. The efficiency of the transmission line is approximately :

(1) 72% (2) 91 % (3) 85% (4) 96%

Sol. 4

$\eta = \frac{P_{out}}{(P_{out} + P_{loss})} \times 100$

$I = \frac{P}{V} = \frac{100}{220} = \frac{5}{11}$ A

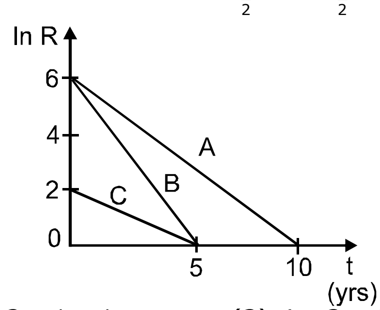
$P_{loss} = I^2R$

$= \left(\frac{50}{11}\right)^2 \times 2 = 41.322$

$\eta = \frac{1000}{1000 + 41.322} \times 100$

$\eta = 96\%$

11. Activities of three radioactive substances A, B and C are represented by the curves A, B and C, in the figure. Then their half-lives $T_{\frac{1}{2}}(A) : T_{\frac{1}{2}}(B) : T_{\frac{1}{2}}(C)$ are in the ratio :



(1) 3 : 2 : 1 (2) 2 : 1 : 1 (3) 4 : 3 : 1 (4) 2 : 1 : 3

Sol. 4

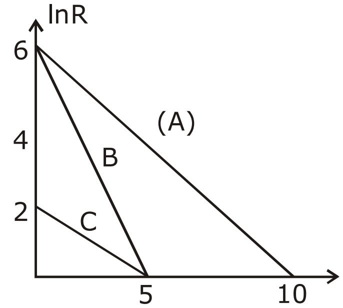
$R = R_0 e^{-\lambda(t)}$

(λ = slope of graph)

$\lambda_A = \frac{6}{10} = \frac{\ln 2}{T_A}$

$\lambda_B = \frac{6}{5} = \frac{\ln 2}{T_B}$

$\lambda_C = \frac{2}{5} = \frac{\ln 2}{T_C}$



$$\left.\begin{array}{l} T_A = \frac{5}{3}\ln 2 \\ T_B = \frac{5}{6}\ln 2 \\ T_C = \frac{5}{2}\ln 2 \end{array}\right\} \Rightarrow T_A : T_B : T_C = \frac{1}{3} : \frac{1}{6} : \frac{1}{2}$$

$= 2 : 1 : 3$

12. The value of the acceleration due to gravity is g_1 at a height $h = \frac{R}{2}$ (R = radius of the earth) from the surface of the earth. It is again equal to g_1 at a depth d below the surface of the earth. The ratio $\left(\frac{d}{R}\right)$ equals :

(1) $\frac{4}{9}$ (2) $\frac{1}{3}$ (3) $\frac{5}{9}$ (4) $\frac{7}{9}$

Sol. 3

$g_{at\ high} = g_{at\ depth}$

$g_{surface} = \frac{GM}{R^2}$

$g\left(1 - \frac{d}{R}\right) = \frac{GMe}{(R+h)^2}$

$g\left(1 - \frac{d}{R}\right) = \frac{GM}{R^2\left(1+\frac{h}{R}\right)^2} = \frac{g}{\left(1+\frac{R}{2R}\right)^2} = \frac{4g}{9}$

$\frac{d}{R} = 1 - \frac{4}{9} = \frac{5}{9}$

13. A hollow spherical shell at outer radius R floats just submerged under the water surface.

The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t water, the value of r is:

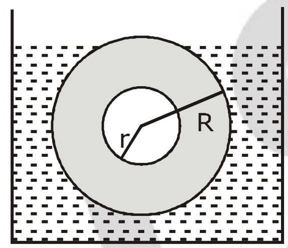
(1) $\frac{4}{9}$ R (2) $\frac{8}{9}$ R (3) $\frac{1}{3}$ R (4) $\frac{2}{3}$ R

Sol. **2**

$F_B = mg$

$\rho_\ell V_{body} g = \rho_b V_b g$

(displaced water) where mater present



$\frac{4}{3}\pi R^3 = \frac{\rho_b}{\rho_\ell}\left(\frac{4}{3}\pi R^3 - \frac{4}{3}\pi r^3\right)$

$R^3 = \frac{27}{8}(R^3 - r^3)$

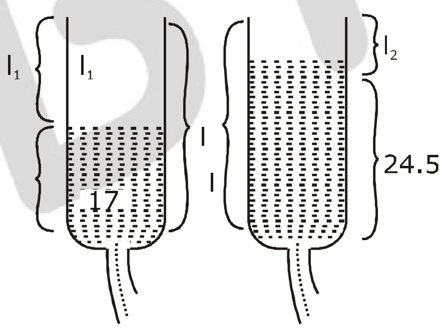
$\frac{8}{27}R^3 = R^3 - r^3 \Rightarrow r^3 = R^3 - \frac{8R^3}{27} = \frac{19}{27}R^3$

$r = \frac{(19)^{1/3}}{3}R \approx 0.88 \approx \frac{8}{9}R$

14. In a resonance tube experiment when the tube is filled with water up to a height of 17.0 cm from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of 24.5 cm. If the velocity of sound in air is 330 m/s, the tuning fork frequency is :

(1) 2200 Hz (2) 550 Hz (3) 3300 Hz (4) 1100 Hz

Sol. **1**



$\ell_1 = \ell - 17$

$\ell_2 = \ell - 24.5$

$v = 2f(\ell_1 - \ell_2)$

$330 = 2 \times f \times [(f \times [(\ell - 17) - (\ell - 24.5)] \times 10^{-2}$

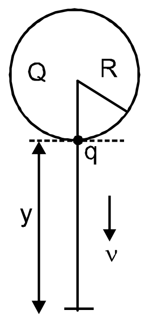
$165 = f \times 7.5 \times 10^{-2}$

$f = \frac{165 \times 100}{7.5}$

$f = 2200$ Hz

15. A solid sphere of radius R carries a charge Q + q distributed uniformly over its volume.

A very small point like piece of it of mass m gets detached from the bottom of the sphere and falls down vertically under gravity. This piece carries charge q. If it acquires a speed ν when it has fallen through a vertical height y (see figure), then : (assume the remaining portion to be spherical).



(1) $\nu^2 = 2y\left[\frac{qQ}{4\pi\epsilon_0 R(R+y)m}+g\right]$

(2) $\nu^2 = 2y\left[\frac{QqR}{4\pi\epsilon_0 (R+y)^3 m}+g\right]$

(3) $\nu^2 = y\left[\frac{qQ}{4\pi\epsilon_0 R(R+y)m}+g\right]$

(4) $\nu^2 = y\left[\frac{qQ}{4\pi\epsilon_0 R^2 ym}+g\right]$

Sol. **1**

M.E.C.

$K_A + U_A = K_B + U_B$

$0 + mgy + qV_A = \frac{1}{2}mv^2 + 0 + (+qv_B)$

$mgy + qV_A = \frac{1}{2}mv^2 + q(V_B)$

$mgy + \frac{qk(Q)}{R} = \frac{1}{2}mv^2 + \frac{qk(Q)}{R+y}$

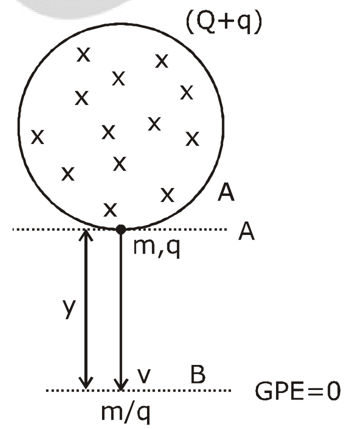
$\frac{1}{2}mv^2 = -\frac{kq(Q)}{R+y} + \frac{kq(Q)}{R} + mgy$

$\frac{mv^2}{2} = \frac{-kq(Q)R + kq(Q)(R+y)}{R(R+y)} + mgy$

$v^2 = \frac{2}{m}\left[\frac{-kqQR + kqQR + kqQ}{R(R+y)} + mgy\right]$

$v^2 = \frac{2}{m}\left[\frac{kq(Q)y}{R(R+y)} + mgy\right]$

$v^2 = 2y\left[\frac{q(Q)}{4\pi\varepsilon_0 R(R+y)m} + g\right] = 2y\left[\frac{qQ}{4\pi\varepsilon_0 R(R+y)m} + g\right]$



potential at A

$V_A = \frac{k(Q+q)}{R}$

$V_B = \frac{k(Q+q)}{R+y}$

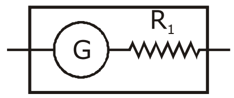
16. A galvanometer of resistance G is converted into a voltmeter of range 0 – 1V by connecting a resistance R_1 in series with it. The additional resistance that should be connected in series with R_1 to increase the range of the voltmeter to 0 – 2V will be :

(1) G (2) R_1 (3) R_1 – G (4) R_1 + G

Sol. **4**

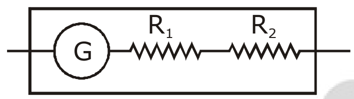
$V = I(R_1 + G)$

$$\frac{1}{2} = \frac{I(R_1 + G).....(i)}{I(R_1 + R_2 + G).....(ii)}$$



V=0

$$\frac{1}{2} = \frac{R_1 + G}{R_1 + R_2 + G}$$



V=0 → 2

$R_1 + R_2 + G = 2R_1 + 2G$

$R_2 = R_1 + G$

17. Number of molecules in a volume of 4 cm^3 of a perfect monoatomic gas at some temperature T and at a pressure of 2 cm of mercury is close to ? (Given, mean kinetic energy of a molecule (at T) is 4×10^{-14} erg, g = 980 cm/s^2, density of mercury = 13.6 g/cm^3)

(1) 4.0×10^{18} (2) 4.0×10^{6} (3) 5.8×10^{16} (4) 5.8×10^{18}

Sol. **1**

$$KE = \frac{3}{2}kT \Rightarrow \left(T = \frac{2E}{3k}\right), PV = NkT$$

$P = \rho gh$, $V = 4cm^3$

$13.6 \times 10^3 \times 9.8 \times 2 \times 10^{-2} \times 4 \times 10^{-6}$

$$= Nk \times \frac{2E}{3k} = \frac{N \times 2}{3} \times 4 \times 10^{-14} \times 10^{-7}$$

$$N = \frac{13.6 \times 19.6 \times 4 \times 10^{-5} \times 3 \times 10^{-21}}{8}$$

$N = 399.84 \times 10^{16}$

$= 3.99 \times 10^{18}$

$N = 4 \times 10^{18}$

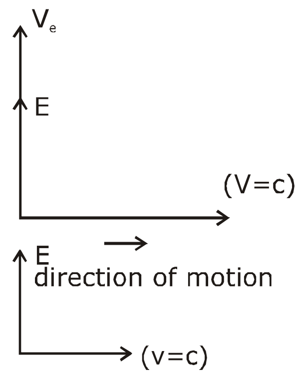
18. An electron is constrained to move along the y-axis with a speed of 0.1 c (c is the speed of light) in the presence of electromagnetic wave, whose electric field is $\vec{E} = 30\,\hat{j}\,\sin(1.5 \times 10^7 t - 5 \times 10^{-2} x)$ V/m. The maximum magnetic force experienced by the electron will be :

(given $c = 3 \times 10^8\ ms^{-1}$ and electron charge $= 1.6 \times 10^{-19}$C)

(1) 2.4×10^{-18} N (2) 4.8×10^{-19} N (3) 3.2×10^{-18} N (4) 1.6×10^{-19} N

Sol. **2**

v_e = 0.1C along y-axis direction of emwave - along (x)



$\vec{E} = \vec{v} \times \vec{B}$
E = CB $\Rightarrow$ B = E/C
$\therefore$ force on e^- will be max.
If B is $\perp$ to y-along z-axis
[$\because$ E also $\perp$ B, B also $\perp$ to direction of motion of wave]
$\therefore$ B $\rightarrow$ along Bz (–z) as

$B = \frac{30}{C} \sin(1.5 \times 10^7 t - 5 \times 10^{-2} x)$

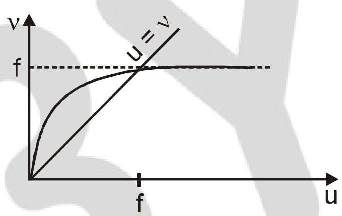
$B_{max} = \frac{30}{3 \times 10^8} = 10^{-7}$ T

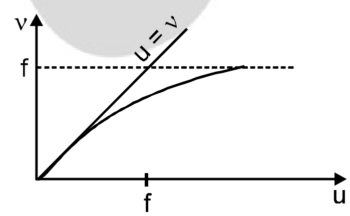
θ = 90 between v_e & B so F_{max} =qvB

$F_{max} = e \times (0.1 \times C) \times \frac{30}{C}$

$= 1.6 \times 10^{-19} \times 3$
$F_{max} = 4.8 \times 10^{-19}$ N

19. For a concave lens of focal length f, the relation between object and image distances u and v, respectively, from its pole can best be represented by (u = ν is the reference line) :

(1)


(2)


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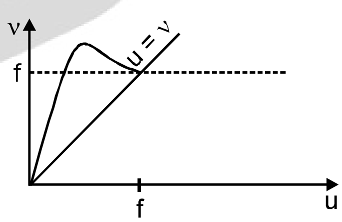
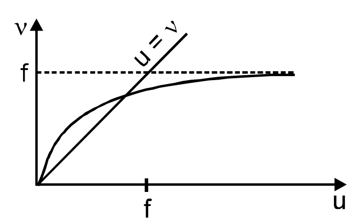


(4)


Sol. **2**

from lens formula

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$v=\frac{uf}{u+f}$$

At reference line (u = v)
u = 0
At u = ∞
v=f
for exact idea of curve slope at u = 0 will be 45^0

$$\left[\frac{dv}{du}\right]_{u=0}=1$$

wich is true only for option (2)

20. A physical quantity z depends on four observables a, b, c and d, as z = $\frac{a^2b^{\frac{2}{3}}}{\sqrt{c}\,d^3}$. The percentages of error in the measurement of a, b, c and d are 2% , 1.5%, 4% and 2.5% respectively. The percentage of error in z is :
(1) 16.5 % (2) 12.25 % (3) 13.5% (4) 14.5%

Sol. **4**
$z = a^2b^{2/3}c^{-1/2}d^{-3}$

$$100 \times \frac{dz}{z} = \left(2\frac{da}{a}+\frac{2}{3}\frac{db}{b}+\frac{1}{2}\frac{dc}{c}+3\frac{d(d)}{(d)}\right)\times 100$$

% error in z

$$= \left(2\times 2+\frac{2}{3}\times 1.5+\frac{1}{2}\times 4+3\times 2.5\right)\%$$

= 4 + 1 + 2 + 7.5
=14.5 %

21. A particle of mass 200 Me V/c^2 collides with a hydrogen atom at rest. Soon after the collision the particle comes to rest, and the atom recoils and goes to its first excited state. The initial kinetic energy of the particle (in eV) is $\frac{N}{4}$. The value of N is :
(Given the mass of the hydrogen atom to be 1 GeV/c^2)_____.

Sol. **51**
m_H = 1GeVC^2 = 1000 MeV/C^2, $m_{particle}$ = 200 meV/c^2 = m

$\therefore \ mv_0 + 0 = 0 + 5\,mV' \Rightarrow v' = \frac{v_0}{5}$

loss in KE

$= \frac{1}{2}\,mv_0^{\,2} - \frac{1}{2}\,(5m)\left(\frac{v_0}{5}\right)^2$

$= \frac{4}{5}\left(\frac{mv_0^2}{2}\right) = \frac{4}{5}\,k$

$\frac{4}{5}\,k = 10.2$

$k = 12.75\ eV = \frac{12.75}{100} = \frac{51}{4}$

so = n = 51

22. Two concentric circular coils, C_1 and C_2, are placed in the XY plane. C_1 has 500 turns, and a radius of 1 cm. C_2 has 200 turns and radius of 20 cm. C_2 carries a time dependent current $I(t) = (5t^2 - 2t + 3)$ A where t is in s. The emf induced in C_1 (in mV), at the instant t = 1s is $\frac{4}{x}$. The value of x is_____.

Sol. 5

$B_2 = \frac{\mu_0 I_2 N_2}{2R_2}$

$\phi = N_1 B_2 \pi R_1^{\,2} = N_1 N_2\,\frac{\mu_0 I}{2R_2}\,\pi R_1^{\,2}$

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

$\phi = \frac{500 \times 200 \times 4\pi \times 10^{-7} \times (5t^2 - 2t - 3)\pi(10^{-2})^2}{2 \times 20 \times 10^{-2}}$

$\frac{10^5 \times 4\pi^2 \times 10^{-7}(5t^2 - 2t + 3) \times 10^{-4}}{40 \times 10^{-2}}$

$\phi = (5t^2 - 2t + 3) \times 10^{-4}$

BYJU'S

$e = \left|\frac{d\phi}{dt}\right| = (10t-2) \times 10^{-4}$

t = 1sec

$e = 8 \times 10^{-4} = 0.8 \text{ mV} = \frac{8}{10} = \frac{4}{5}$

x = 5

23. A beam of electrons of energy E scatters from a target having atomic spacing of 1Å. The first maximum intensity occurs at $\theta = 60°$ Then E (in eV) is ______.
(Planck constant $h = 6.64 \times 10^{-34}$ Js, 1 eV = 1.6×10^{-19} J,
electron mass $m = 9.1 \times 10^{-31}$ kg)

Sol. **50**

$2d\sin\theta = n\lambda = 1 \times \sqrt{\frac{150}{v}} \times 10^{-10}$, $\theta = 90 - \frac{\phi}{2}$

$2 \times 10^{-10} \times \sin 60 = \sqrt{\frac{150}{V}} \times 10^{-10}$, $\theta = 90 - \frac{60}{2} = 60$

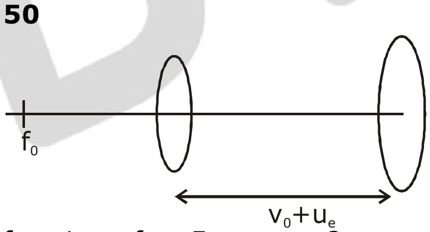
$2 \times \frac{\sqrt{3}}{2} = \sqrt{\frac{150}{V}}$

$V = \frac{150}{3} = 50$ volt

E = qv = ev = 50ev

24. A compound microscope consists of an objective lens of focal length 1 cm and an eye piece of focal length 5 cm with a separation of 10 cm. The distance between an object and the objective lens, at which the strain on the eye is minimum is $\frac{n}{40}$ cm. The value of n is _____.

Sol. **50**



$f_0 = 1$cm, $f_e = 5$ cm, $u_0 = ?$
final image at (∞)
($v_e = \infty$)

$v_0 + u_e = 10$cm ...(i)

$v_0 + 5 = 10$

$v_0 = 5$ cm

$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

$L = v_0 + u_e = 10$ cm

$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$\frac{1}{\infty} - \frac{1}{u_e} = \frac{1}{5}$

$u_e = -5$cm

$\frac{1}{5} - \frac{1}{u_0} = \frac{1}{1}$ $\quad\quad |u_e| = 5$

$\frac{1}{u_0} = \frac{1}{5} - 1 = -\frac{4}{5} \Rightarrow u_0 = -\frac{4}{5}$

$|u_0| = \frac{5}{4} = \frac{50}{40} = \frac{n}{40}$

$\therefore$ n = 50

25. A force $\vec{F} = (\hat{i} + 2\hat{j} + 3\hat{k})$ N acts at a point $(4\hat{i} + 3\hat{j} - \hat{k})$ m. Then the magnitude of torque about the point $(\hat{i} + 2\hat{j} + \hat{k})$ m will be $\sqrt{x}$ N–m. The value of x is _______.

Sol. **195**

$\vec{\tau} = \vec{r} \times F = (3\hat{i} + \hat{j} - 2\hat{k}) \times (\hat{i} + 2\hat{j} + 3\hat{k})$

$$= \begin{vmatrix} i & j & k \\ 3 & 1 & -2 \\ 1 & 2 & 3 \end{vmatrix}$$

$\hat{i}(3 + 4) - \hat{j}(9 + 2) + \hat{k}(6 - 1)$

$\vec{\tau} = 7\hat{j} - 11\hat{j} + 5\hat{k}$

$|\vec{\tau}| = \sqrt{49 + 121 + 25} = \sqrt{195}$

x = 195