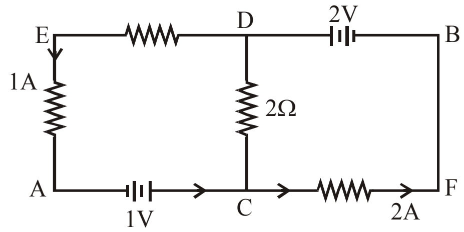
FINAL JEE–MAIN EXAMINATION – SEPTEMBER, 2020

(Held On Saturday 05th SEPTEMBER, 2020) TIME : 3 PM to 6 PM

PHYSICS — TEST PAPER WITH ANSWER & SOLUTION

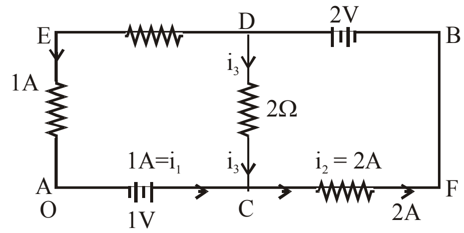
1. In the circuit, given in the figure currents in different branches and value of one resistor are shown. Then potential at point B with respect to the point A is :



(1) +1V (2) – 1V (3) – 2V (4) +2V

Official Ans. by NTA (1)

Sol.



Let us asssume the potential at A = $V_A = 0$

Now at junction C, According to KCL

$i_1 + i_3 = i_2$

$1A + i_3 = 2A$

$i_3 = 2A$

Now Analyse potential along ACDB

$v_A + 1 + i_3(2) - 2 = v_B$

$0 + 1 + 2(1) - 2 = v_B$

$v_B = 3 - 2$

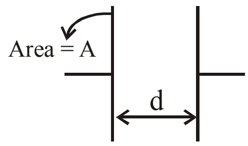
$v_B = 1$ Amp

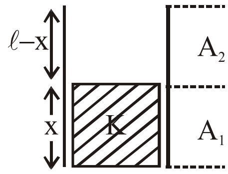
2. A parallel plate capacitor has plate of length 'l', width 'w' and separation of plates is 'd'. It is connected to a battery of emf V. A dielectric slab of the same thickness 'd' and of dielectric constant k = 4 is being inserted between the plates of the capacitor. At what length of the slab inside plates, will be energy stored in the capacitor be two times the initial energy stored?

(1) $l / 4$ (2) $l / 2$ (3) $l / 3$ (4) $2l / 3$

Official Ans. by NTA (3)

Sol.





Before inserting slab

$C_i = \frac{\varepsilon_0 A}{d}$

$C_i = \frac{\varepsilon_0 \ell w}{d}$

After inserting dielectric slab

$C_f = C_1 + C_2$

$C_f = \frac{K\varepsilon_0 A_1}{d} + \frac{\varepsilon_0 A_2}{d}$

$$C_f = \frac{K\varepsilon_0 wx}{d} + \frac{\varepsilon_0 w(\ell - x)}{d}$$

$$C_f = 2C_i \Rightarrow \frac{K\varepsilon_0 wx}{x} + \frac{\varepsilon_0 w(\ell - x)}{d} = \frac{2\varepsilon_0 \ell w}{d}$$

$$4x + \ell - x = 2\ell$$

$$\boxed{x = \frac{\ell}{3}}$$

3. Ten charges are placed on the circumference of a circle of radius R with constant angular separation between successive charges. Alternate charges 1, 3, 5, 7, 9 have charge (+q) each, while 2, 4, 6, 8, 10 have charge (–q) each. The potential V and the electric field E at the centre of the circle are respectively:
(Take V = 0 at infinity)

(1) $V = \frac{10q}{4\pi\epsilon_0 R}; E = \frac{10q}{4\pi\epsilon_0 R^2}$

(2) $V = 0, E = \frac{10q}{4\pi\epsilon_0 R^2}$

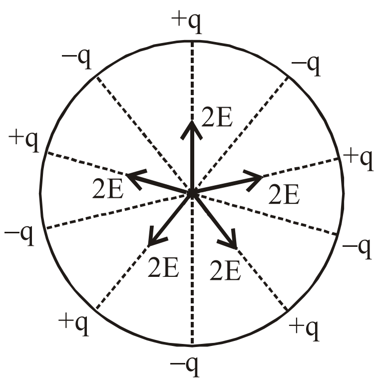
(3) V = 0, E = 0

(4) $V = \frac{10q}{4\pi\epsilon_0 R}; E = 0$

Official Ans. by NTA (3)

Sol. Potential of centre = V = $\Sigma\left(\frac{kq}{R}\right)$

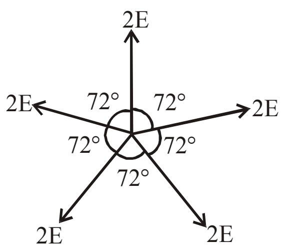
$$V_C = \frac{K(\Sigma q)}{R}$$



$$V_C = \frac{K(0)}{R} = 0$$

Electric field at centre $\vec{E}_B = \Sigma\vec{E}$

Let E be electric field produced by each charge at the centre, then resultant electric field will be



E_C = 0, Since equal electric field vectors are acting at equal angle so their resultant is equal to zero.

4. An iron rod of volume 10^{-3} m^3 and relative permeability 1000 is placed as core in a solenoid with 10 turns/cm. If a current of 0.5 A is passed through the solenoid, then the magnetic moment of the rod will be :

(1) 0.5×10^2 Am^2 (2) 50×10^2 Am^2

(3) 500×10^2 Am^2 (4) 5×10^2 Am^2

Official Ans. by NTA (4)

Sol. $M = \mu_r NiA$

Here

μ_r = Relative permeability

N = No. of turns

i = Current

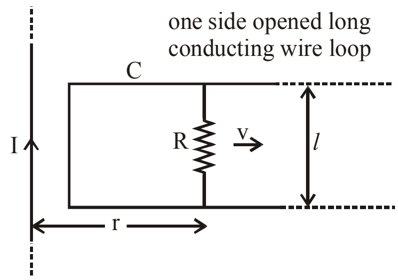
A = Aea of cross section

$M = \mu_r NiA = \mu_r n\ell iA$

$M = \mu_r niV = 1000(1000)\ 0.5\ (10^{-3})$

$= 500 = 5 \times 10^2\ Am^2$

5. An infinitely long straight wire carrying current I, one side opened rectangular loop and a conductor C with a sliding connector are located in the same plane, as shown in the figure. The connector has length l and resistance R. It slides to the right with a velocity v. The resistance of the conductor and the self inductance of the loop are negligible. The induced current in the loop, as a function of separation r, between the connector and the straight wire is :

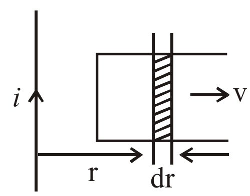


(1) $\frac{\mu_0}{\pi}\frac{Ivl}{Rr}$ (2) $\frac{\mu_0}{2\pi}\frac{Ivl}{Rr}$

(3) $\frac{2\mu_0}{\pi}\frac{Ivl}{Rr}$ (4) $\frac{\mu_0}{4\pi}\frac{Ivl}{Rr}$

Official Ans. by NTA (2)

Sol. $B = \frac{\mu_0 i}{2\pi r}$



$$\phi = \frac{\mu_0 i}{2\pi r}\ell dr$$

$$\Rightarrow \frac{d\phi}{dt} = \frac{\mu_0 i\ell}{2\pi r}\cdot\frac{dr}{dt}$$

$$\Rightarrow e = \frac{\mu_0}{2\pi}\cdot\frac{iv\ell}{r}$$

$$i = \frac{e}{R} = \frac{\mu_0}{2\pi}\cdot\frac{iv\ell}{Rr}$$

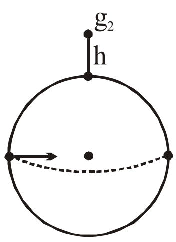
6. The acceleration due to gravity on the earth's surface at the poles is g and angular velocity of the earth about the axis passing through the pole is ω. An object is weighed at the equator and at a height h above the poles by using a spring balance. If the weights are found to be same, then h is : (h<<R, where R is the radius of the earth)

(1) $\frac{R^2\omega^2}{8g}$ (2) $\frac{R^2\omega^2}{4g}$ (3) $\frac{R^2\omega^2}{g}$ (4) $\frac{R^2\omega^2}{2g}$

Official Ans. by NTA (4)

Sol. $g_e = g - R\omega^2$

$g_2 = g\left(1-\frac{2h}{R}\right)$ $g_1 = ge$

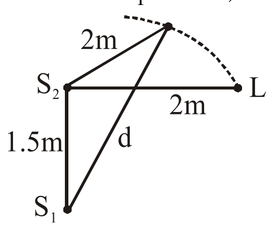


$g_2 = g - \frac{2gh}{R}$

Now $R\omega^2 = \frac{2gh}{R}$

$h = \frac{R^2\omega^2}{2g}$

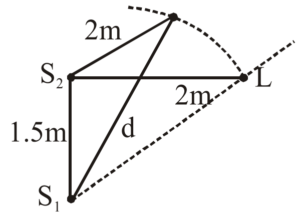
7. Two coherent sources of sound, S_1 and S_2, produce sound waves of the same wavelength, λ = 1 m, in phase. S_1 and S_2 are placed 1.5 m apart (see fig.) A listener, located at L, directly in front of S_2 finds that the intensity is at a minimum when he is 2m away from S_2. The listener moves away from S_1, keeping his distance from S_2 fixed. The adjacent maximum of intensity is observed when the listener is at a distance d from S_1. Then, d is :



(1) 12m (2) 3m (3) 5m (4) 2m

Official Ans. by NTA (2)

Sol.



Initially $S_2L = 2m$

$S_1L = \sqrt{2^2 + (3/2)^2}$

$S_1L = \frac{5}{2} = 2.5$ m

$\Delta x = S_1L - S_2L = 0.5$ m

So since λ = 1m $\therefore \Delta x = \frac{\lambda}{2}$

So while listener moves away from S_1

Then, Δx (= $S_1L - S_2L$) increases

and hence, at $\Delta x = \lambda$ first maxima will appear.

$\Delta x = \lambda = S_1L - S_2L$

$1 = d - 2 \Rightarrow d = 3m$

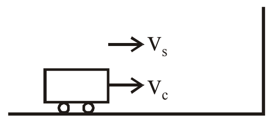
8. A driver in a car, approaching a vertical wall notices that the frequency of his car horn, has changed from 440 Hz to 480 Hz, when it gets reflected from the wall. If the speed of sound in air is 345 m/s, then the speed of the car is

(1) 36 km/hr (2) 24 km/hr

(3) 18 km/hr (4) 54 km/hr

Official Ans. by NTA (4)

Sol.



f_1 = frequency heard by wall = $f_s = \left(\frac{v_s}{v_s - v_c}\right)$

f_2 = frequency heard by driver after reflection from wall

$f_2 = \left(\frac{v_s + v_c}{v_s}\right)f_1 = \left(\frac{v_s + v_c}{v_s - v_c}\right)f_0$

$\frac{f_2}{f_0} = \frac{v_s - v_c}{v_s + v_c}$

$\frac{48}{44} = \frac{v_s - v_c}{v_s + v_c}$

$12(v_s + v_c) = 11(v_s - v_c)$

$23v_c = v_s$

$v_c = \frac{v_s}{23} = \frac{345}{23} = 15 m/s$

$= \frac{15 \times 18}{5}$ = 54 km/hr

9. In an adiabatic process, the density of a diatomic gas becomes 32 times its initial value. The final pressure of the gas is found to be n times the initial pressure. The value of n is:

(1) 326 (2) $\frac{1}{32}$ (3) 32 (4) 128

Official Ans. by NTA (4)

Sol. In adiabatic process

PV^{γ} = constant

$$P\left(\frac{m}{\rho}\right)^{\gamma} = \text{constant}$$

as mass is constant

$P \propto \rho^{\gamma}$

$$\frac{P_f}{P_i} = \left(\frac{\rho_f}{\rho_i}\right)^{\gamma} = (32)^{7/5} = 2^7 = 128$$

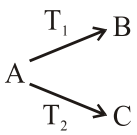
10. A radioactive nucleus decays by two different processes. The half life for the first process is 10 s and that for the second is 100s. the effective half life of the nucleus is close to:

(1) 9 sec (2) 55 sec

(3) 6 sec (4) 12 sec

Official Ans. by NTA (1)

Sol.



$$\frac{1}{T_{eff}} = \frac{1}{T_1} + \frac{1}{T_2}$$

$$T_{eff} = \frac{T_1T_2}{T_1 + T_2} = \frac{1000}{110} = \frac{100}{11} = 9.09$$

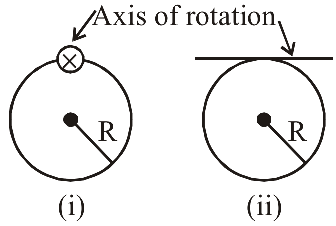
$$T_{eff} \simeq 9$$

11. A ring is hung on a nail. It can oscillate, without slipping or sliding (i) in its plane with a time period T_1 and, (ii) back and forth in a direction perpendicular to its plane, with a period T_2. the ratio $\frac{T_1}{T_2}$ will be :

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

Official Ans. by NTA (1)

Sol.



Moment of inertia in case (i) is I_1

Moment of inertia in case (ii) is I_2

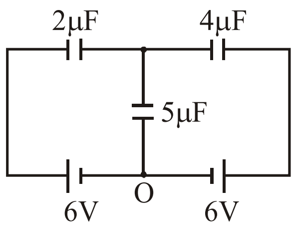
$I_1 = 2MR^2$

$$I_2 = \frac{3}{2}MR^2$$

$$T_1 = 2\pi\sqrt{\frac{I_1}{Mgd}} \; ; \; T_2 = 2\pi\sqrt{\frac{I_2}{Mgd}}$$

$$\frac{T_1}{T_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{2MR^2}{\frac{3}{2}MR^2}} = \frac{2}{\sqrt{3}}$$

12. In the circuit shown, charge on the 5 μF capacitor is :

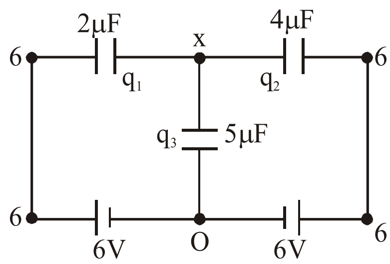


(1) 5.45 μC (2) 16.36 μC

(3) 10.90 μC (4) 18.00 μC

Official Ans. by NTA (2)

Sol.



Let potential of point O $v_0 = 0$

Now, using junction analysis

We can say, $q_1 + q_2 + q_3 = 0$

$2(x - 6) + 4(x - 6) + 5(x) = 0$

$$x = \frac{36}{11} \qquad q_3 = \frac{36(5)}{11} = \frac{180}{11}$$

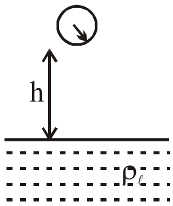
$q_3 = 16.36$ μC

13. In an experiment to verify Stokes law, a small spherical ball of radius r and density ρ falls under gravity through a distance h in air before entering a tank of water. If the terminal velocity of the ball inside water is same as its velocity just before entering the water surface, then the value of h is proportional to :
(ignore viscosity of air)

(1) r (2) r^4 (3) r^3 (4) r^2

Official Ans. by NTA (2)

Sol.



After falling through h, the velocity be equal to terminal velocity

$$\sqrt{2gh} = \frac{2}{9}\frac{r^2 g}{\eta}(\rho_\ell - \rho)$$

$$\Rightarrow h = \frac{2}{81}\frac{r^4 g(\rho_\ell - \rho)^2}{\eta^2}$$

$\Rightarrow h \propto r^4$

14. Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion α_1 and α_2, are joined end-to-end. Then the effective temperature coefficient of linear expansion is :

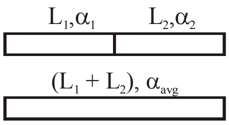
(1) $4\frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}\frac{L_2L_1}{(L_2+L_1)^2}$ (2) $2\sqrt{\alpha_1\alpha_2}$

(3) $\frac{\alpha_1+\alpha_2}{2}$ (4) $\frac{\alpha_1L_1+\alpha_2L_2}{L_1+L_2}$

Official Ans. by NTA (4)

Sol. At T°C $L = L_1 + L_2$

At T + ΔT $L'_{eq} = L'_1 + L'_2$



where $L'_1 = L_1(1+\alpha_1\Delta T)$

$L'_2 = L_2(1+\alpha_2\Delta T)$

$L'_{eq} = (L_1+L_2)(1+\alpha_{avg}\Delta T)$

$\Rightarrow (L_1+L_2)(1+\alpha_{avg}\Delta T) = L_1+L_2+L_1\alpha_1\Delta T + L_2\alpha_2\Delta T$

$\Rightarrow (L_1 + L_2)\,\alpha_{avg} = L_1\alpha_1 + L_2\alpha_2$

$$\Rightarrow \alpha_{avg} = \frac{L_1\alpha_1 + L_2\alpha_2}{L_1 + L_2}$$

15. The quantities $x = \frac{1}{\sqrt{\mu_0 \in_0}}$, $y = \frac{E}{B}$ and $z = \frac{1}{CR}$ are defined where C-capacitance, R-Resistance, l-length, E-Electric field, B-magnetic field and $\in_0$, μ_0,-free space permittivity and permeability respectively. Then :

(1) Only x and y have the same dimension

(2) x, y and z have the same dimension

(3) Only x and z have the same dimension

(4) Only y and z have the same dimension

Official Ans. by NTA (2)

Sol. $x = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = \text{speed} \Rightarrow [x] = [L^1T^{-1}]$

$y = \frac{E}{B} = \text{speed} \Rightarrow [y] = [L^1T^{-1}]$

$z = \frac{\ell}{RC} = \frac{\ell}{\tau} \Rightarrow [z] = [L^1T^{-1}]$

So, x, y, z all have the same dimensions.

16. A galvanometer is used in laboratory for detecting the null point in electrical experiments. If, on passing a current of 6mA it produces a deflection of 2°, its figure of merit is close to :

(1) 3×10^{-3} A/div.

(2) 333° A/div.

(3) 6×10^{-3} A/div.

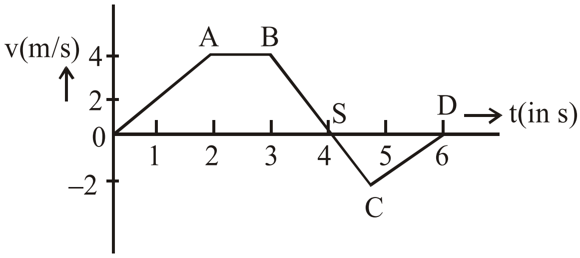
(4) 666° A/div.

Official Ans. by NTA (1)

Sol. Figure of Merit = C = $\frac{i}{\theta}$

$$= C = \frac{6\times10^{-3}}{2} = 3\times10^{-3}\,Am^2$$

17. The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6s is :

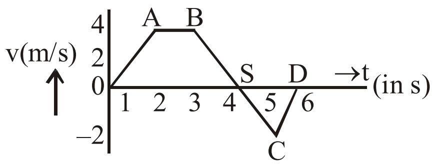


(1) 12m (2) $\frac{49}{4}$ m

(3) 11 m (4) $\frac{37}{3}$ m

Official Ans. by NTA (4)

Sol.



OS = $4+\frac{1}{3}=\frac{13}{3}$

SD = $2-\frac{1}{3}=\frac{5}{3}$

Area of OABS is A_1

Area of SCD is A_2

Distance = $|A_1| + |A_2|$

$A_1 = \frac{1}{2}\left[\frac{13}{3}+1\right]4=\frac{32}{3}$

$A_2 = \frac{1}{2}\times\frac{5}{3}\times 2=\frac{5}{3}$

Distance = $|A_1| + |A_2|$

$=\frac{32}{3}+\frac{5}{3}$

$=\frac{37}{3}$

18. A spaceship in space sweeps stationary interplanetary dust. As a result, its mass increases at a rate $\frac{dM(t)}{dt}=bv^2(t)$, where v(t) is its instantaneous velocity. The instantaneous acceleration of the satellite is:

(1) $-\frac{2bv^3}{M(t)}$

(2) $-\frac{bv^3}{2M(t)}$

(3) $-bv^3(t)$

(4) $-\frac{bv^3}{M(t)}$

Official Ans. by NTA (4)

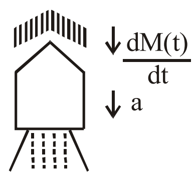
Sol. $\frac{dm(t)}{dt}=bv^2$

$F_{thast}=v\frac{dm}{dt}$

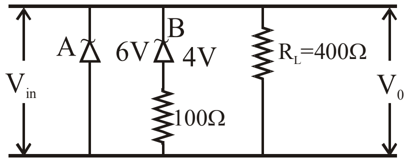
Force on statellile = $-\vec{v}\frac{dm(t)}{dt}$

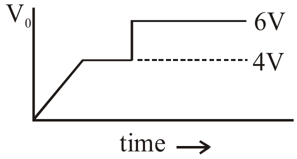
$M(t)\ a = -v\ (bv^2)$

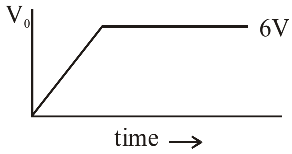
$\boxed{a=a\frac{bv^3}{M(t)}}$



19. Two Zener diodes (A and B) having breakdown voltages of 6V and 4V respectively, are connected as shown in athe circuit below. The output voltage V_0 variation with input voltage linearly increasing with time, is given by : (V_{input} = 0V at t = 0) (figures are qualitative)



(1)


(2)


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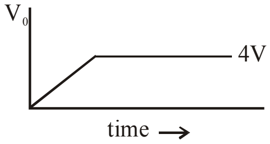

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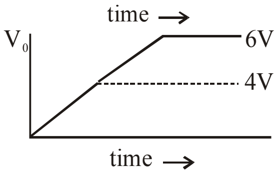


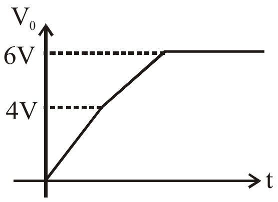
Official Ans. by NTA (4)

Official Ans. by ALLEN (2)

Sol. Till input voltage Reaches 4V No zener is in Breakdown Region So $V_0 = V_i$ Then Now when V_i changes between 4V to 6V One Zener with 4V will Breakdown are P.D. across This zener will become constant and Remaining Potential will drop. acro

Resistance in series with 4V Zener.

Now current in circuit increases Abruptly and source must have an internal resistance due to which. Some potential will get drop across the source also so correct graph between V_0 and t. will be



We have to Assume some resistance in series with source.

20. The correct match between the entries in column I and column II are :

I	II
Radiation	**Wavelength**
(a) Microwave	(i) 100m
(b) Gamma rays	(ii) 10^{-15} m
(c) A.M. radio waves	(iii) 10^{-10} m
(d) X-rays	(iv) 10^{-3} m

(1) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

(2) (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)

(3) (a)-(iii), (b)-(ii), (c)-(i), (d)-(iv)

(4) (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)

Official Ans. by NTA (4)

Sol. Energes of given Radiation can have The following relation

$E_{\gamma\text{-Rays}} > E_{\text{X-Rays}} > E_{\text{microwave}} > E_{\text{AM Radiowaves}}$

$\therefore \lambda_{\gamma\text{-Rays}} < \lambda_{\text{X-Rays}} < \lambda_{\text{microwave}} < \lambda_{\text{AM Radiowaves}}$

According To tres.

(a) Microwave → 10^{-3}m (iv)

(b) Gamma Rays → 10^{-15}m (ii)

(c) AM Radio wave → 100 m (i)

(d) X-Rays → 10^{-10}m (iii)

21. The surface of a metal is illuminated alternately with photons of energies E_1 = 4eV and E_2 = 2.5 eV respectively. The ratio of maximum speeds of the photoelectrons emitted in the two cases is 2. The work function of the metal in (eV) is ______.

Official Ans. by NTA (2.00)

Sol. $E_1 = \phi + K_1$...(1)

$E_2 = \phi + K_2$ ...(2)

$E_1 - E_2 = K_1 - K_2$

Now $\frac{V_1}{V_2} = 2$

$\frac{K_1}{K_2} = 4$

$K_1 = 4K_2$

Now from equation (2)

$\Rightarrow 4 - 2.5 = 4K_2 - K_2$

$1.5 = 3K_2$

$K_2 = 0.5$eV

Now putting This

Value in equation (2)

$2.5 = \phi + 0.5$eV

$\boxed{\phi = 2\text{ev}}$

22. Nitrogen gas is at 300°C temperature. The temperature (in K) at which the rms speed of a H_2 molecule would be equal to the rms speed of a nitrogen molecule, is _____.
(Molar mass of N_2 gas 28 g)
Official Ans. by NTA (41.00)
Official Ans. by ALLEN (40.93)

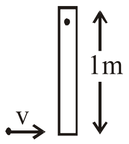
Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$V_{N_2} = V_{H_2}$

$$\sqrt{\frac{3RT_{N_2}}{M_{N_2}}} = \sqrt{\frac{3RT_{H_2}}{M_{H_2}}}$$

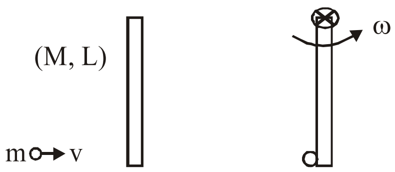
$$\frac{573}{28} = \frac{T_{H_2}}{2} \Rightarrow T_{H_2} = 40.928$$

23. A thin rod of mass 0.9 kg and length 1m is suspended, at rest, from one end so that it can freely oscillate in the vertical plane. A particle of move 0.1 kg moving in a straight line with velocity 80 m/s hits the rod at its bottom most point and sticks to it (see figure). The angular speed (in rad/s) of the rod immediately after the collision will be ______.



Official Ans. by NTA (20.00)

Sol.



Before collision After collision

$\vec{L}_i = \vec{L}_f$

mvL = Iω

$$mvL = \left(\frac{ML^2}{3} + mL^2\right)\omega$$

$$0.1 \times 80 \times 1 = \left(\frac{0.9 \times 1^2}{3} + 0.1 \times 1^2\right)\omega$$

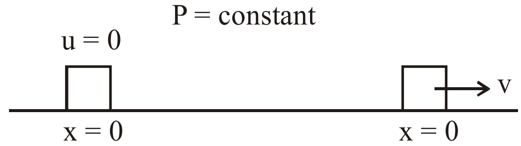
$$8 = \left(\frac{3}{10} + \frac{1}{10}\right)\omega$$

$$8 = \frac{4}{10}\omega$$

$$\omega = 20\ \text{rad}\frac{\text{rad}}{\text{sec}}$$

24. A body of mass 2kg is driven by an engine delivering a constant power 1J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) _______.
Official Ans. by NTA (18.00)

Sol.



P = mav

$$m\frac{dv}{dt}v = P$$

$$\int_0^v v\,dv = \frac{P}{m}\int_0^t dt$$

$$\frac{v^2}{2} = \frac{Pt}{m} \Rightarrow v = \left(\frac{2Pt}{m}\right)^{1/2}$$

$$\frac{dx}{dt} = \sqrt{\frac{2P}{m}}\,t^{1/2}$$

$$\int_0^x dx = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}\,dt$$

$$x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2} = \sqrt{\frac{2P}{m}} \times \frac{2}{3}t^{3/2}$$

$$= \sqrt{\frac{2 \times 1}{2}} \times \frac{2}{3} \times 9^{3/2}$$

$$= \frac{2}{3} \times 27 = 18$$

25. A prism of angle A = 1° has a refractive index μ = 1.5. A good estimate for the minimum angle of deviation (in degrees) is close to N/10. Value of N is ______.
Official Ans. by NTA (5.00)

Sol. $\delta_{min} = (\mu - 1)\,A$
$= (1.5 - 1)1$
$= 0.5$

$$\delta_{min} = \frac{5}{10}$$

N = 5