FINAL NATIONAL STANDARD EXAMINATION - 2019

(Held On Sunday 24th November, 2019)

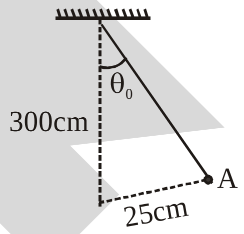
PHYSICS | **TEST PAPER WITH SOLUTION**

1. A pendulum is made by using a thread of length 300 cm and a small spherical bob of mass 100 g. It is suspended from a point S. The bob is pulled from its position of rest at O to the point A so that the linear amplitude is 25 cm. The angular amplitude in radian and the potential energy of the bob in joule at A are respectively

(a) 0.10 and 0.10 (b) 0.083 and 0.01 (c) 0.251 and 2.94 (d) 0.083 and 0.24

Ans. (b)

Sol. Angular amplitude , $\theta_0 = \frac{25}{300}$



$\theta_0 = .083$ rad

potential energy, $U = mg\ell(1 - \cos\theta)$

$U = 2mg\ell \sin^2 (\theta/2)$

$\Rightarrow U \simeq mg\ell\frac{\theta^2}{2}$

$= 0.1 \times 10 \times 3 \times \left(\frac{1}{12}\right)^2 \times \frac{1}{2}$

$= 0.01$ J

2. Consider the following physical expressions

(I) ρv^2 (ρ : density, v : velocity)

(II) $\frac{Y\Delta L}{L}$ (Y : Young's modulus, L : length)

(III) $\frac{\sigma^2}{\varepsilon_0}$ (σ : surface density of charge)

(IV) $h\rho rg$ (h : rise of a liquid in a capillary tube of radius r)

(a) I and II only (b) II and III only (c) II, III and IV only (d) I, II and III only

Ans. (d)

Sol. $[\rho v^2] = [ML^{-3}]\,[L^2T^{-2}]$

$= ML^{-1}T^{-2}$

$\left[Y\frac{\Delta L}{L}\right] = \frac{[F]}{[A]} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

$\left[\frac{\sigma^2}{\epsilon_0}\right] = [\text{Pressure}] = ML^{-1}T^{-2}$

$[h\rho rg] = [ML^{-1}T^{-2}]\,[L] = MT^{-2}$

3. Two simple pendulums of lengths 1.44 m and 1.0 m start swinging together in the same phase. The two will be in phase again after a time of

(a) 6 second (b) 9 second (c) 12 second (d) 25 second

Ans. (c)

Sol. $T_1 = 2\pi\sqrt{\frac{1.44}{10}}$ $T_2 = 2\pi\sqrt{\frac{1}{10}}$

$T_1 = 1.2\ T_0$, $T_2 = T_0$

Let after minimum time t, both will again be in phase,

$n_1T_1 = n_2T_2 = t$

$\Rightarrow n_1 \times 1.2 = n_2 \Rightarrow \frac{n_2}{n_1} = \frac{6}{5}$

minimum value of $n_1 = 5$ & $n_2 = 6$

$\therefore\ t = 6 \times \frac{2\pi}{10} \simeq 12$ second

4. A home aquarium partly filled with water slides down an inclined plane of inclination angle θ with respect to the horizontal. The surface of water in the aquarium

(a) remains horizontal

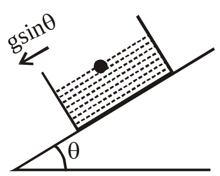
(b) remains parallel to the plane of the incline

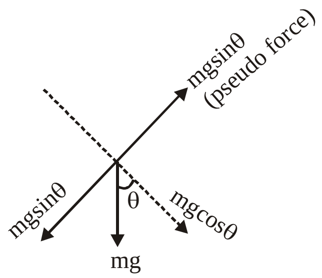
(c) forms an angle α with the horizon where $0 < \alpha < \theta$

(d) forms an angle α with the horizon, where $\theta < \alpha < 90$

Ans. (b or c)

Sol. Considering friction is absent





F.B.D. of a particle in frame of aquarium.

From FBD it can be said that net force (including pseudo force)

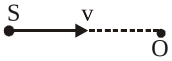
act perpendicular to inclined plane therefore liquid surface will be parallel to incline plane

If friction is present then pseudo force will be less than mgsinθ, therefore $0 < \alpha < \theta$.

5. A sound source of constant frequency travels with a constant velocity past an observer. When it crosses the observer the sound frequency sensed by the observer changes from 449 Hz to 422 Hz. If the velocity of sound in 340 m/s, the velocity of the source of sound is

(a) 8.5 m/s (b) 10.5 m/s (c) 12.5 m/s (d) 14.5 m/s

Ans. (b)

Sol. 

frequency heard by observer when source is approaching observer

$$f_1 = \left[\frac{v}{v - v_s}\right] f_0 = 449 \quad ....(1)$$

frequency heard by observer when source is receding from observer

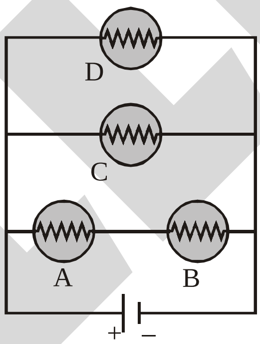
$$f_2 = \left[\frac{v}{v + v_s}\right] f_0 = 422 \quad ...(2)$$

from eq. (1) & (2)

$$\frac{v - v_s}{v + v_s} = \frac{422}{449} \Rightarrow \frac{v_s}{v} = \frac{27}{871}$$

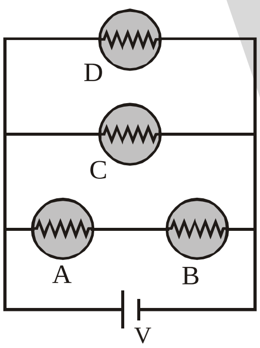
$$\Rightarrow v_s = \frac{27}{871} \times 340 = 10.5 \text{m / s}$$

6. Identify the rank in order from the dimmest to the brightest when all the identical bulbs are connected in the circuit as shown below .



(a) A = B > C = D (b) A = B = C = D (c) A > C > B > D (d) A = B < C = D

Ans. (d)

Sol. 

$$P_A = \frac{V^2}{4R}, \quad P_B = \frac{V^2}{4R}$$

$$P_D = \frac{V^2}{R}, \quad P_C = \frac{V^2}{R}$$

$\therefore P_A = P_B < P_D = P_C$

7. The unit of magnetizing field is

(a) tesla (b) newton (c) ampere (d) ampere turn/meter

Ans. (d)

8. A star undergoes a supernova explosion. Just after the explosion, the material left behind forms a uniform sphere of radius 8000 km with a rotation period of 15 hours. This remaining material eventually collapses into a neutron star of radius 4 km with a period of rotation.

(a) 14 s (b) 3.8 h (c) 0.021 s (d) 0.0135 s

Ans. (d)

Sol. According to angular momentum conservation

$I_1\omega_1 = I_2\omega_2$

$$\Rightarrow \frac{2}{5}mR_1^2\left(\frac{2\pi}{T_1}\right)=\frac{2}{5}mR_2^2\left(\frac{2\pi}{T_2}\right)$$

$$\Rightarrow \frac{(8000)^2}{15}=\frac{(4)^2}{T_2} \Rightarrow T_2=15\left(\frac{1}{2000}\right)^2 \text{hr}$$

$\Rightarrow T_2 = 0.0135$ sec

9. A number of identical absorbing plates are arranged in between a source of light and a photo cell. When there is no plate in between, the photo current is maximum. Under the circumstances let us focus on the two statements -

(1) The photo current decreases with the increase in number of absorbing plates.

(2) The stopping potential increases with the increase in number of absorbing plates.

(a) Statement (1) and (2) are both true and (1) is the cause of (2)

(b) Statement (1) and (2) are both true but (1) and (2) are independent

(c) Statement (1) is true while (2) is not true and (1) and (2) are independent

(d) Statement (1) is true while (2) is not true and (2) is the effect of (1)

Ans. (c)

Sol. due to absorbing plates, intensity of light decreases, but frequency remain same
therefore photo current decreases but stopping potential remain same

10. In a nuclear reaction, two photons each of energy 0.51 MeV are produced by electron-positron annihilation. The wavelength associated with each photon is

(a) 2.44×10^{-12} m (b) 2.44×10^{-8} m
(c) 1.46×10^{-12} m (d) 3.44×10^{-10} m

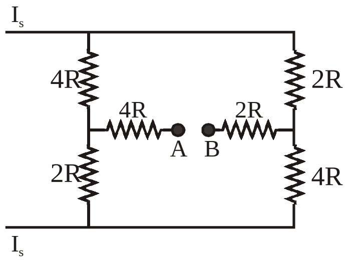
Ans. (a)

Sol. $\frac{hc}{\lambda}=0.51$ MeV $= 0.51 \times 10^6$ eV

$$\lambda=\frac{hC}{5.1\times10^5}=\frac{1242}{5.1\times10^5}\text{nm}$$

$\lambda = 2.44 \times 10^{-12}$ m

11. In the circuit shown if an ideal ammeter is connected between A and B then the direction of current and the current reading would be (assume I_s remains unchanged)

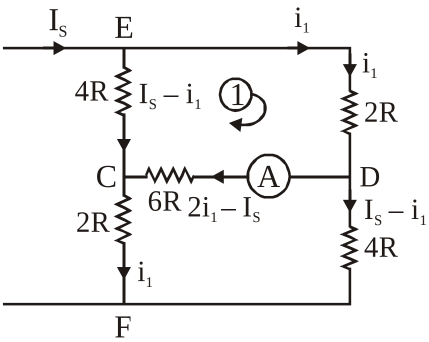


(a) B to A and $I_s/2$ (b) A to B and $I_s/4$

(c) B to A and $I_s/9$ (d) B to A and $I_s/3$

Ans. (c)

Sol.



On applying Kirchhoff's law

in 1 loop

$-2i_1R - 6R(2i_1 - I_S)$

$+ 4R(I_S - i_1) = 0$

$-2i_1 - 12i_1 + 6I_S + 4I_S - 4i_1 = 0$

$-18i_1 + 10I_S = 0$

$i_1 = \frac{5}{9}I_S$

current through ammeter $= 2i_1 - I_S$

$= \left(\frac{10}{9} - 1\right)I_S$

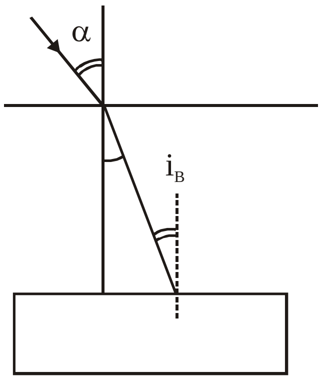
$= \frac{I_S}{9}$ from B to A

12. A rectangular slab of glass of refractive index 1.5 immersed in water of refractive index 1.33 such that the top surface of the slab remains parallel to water level. Light from a point source in air is incident on the surface of water at an angle α such that the light reflected from the glass slab is plane polarised, the angle α is :-

(a) 84.4º (b) 48.4º (c) 56.3º (d) 53.1º

Ans. (a)

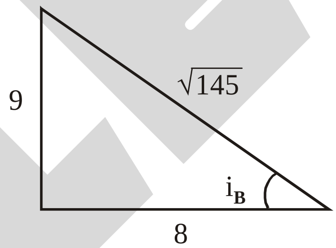
Sol.



i_B = Brewster angle

$\therefore \quad \frac{4}{3}\sin i_B = \frac{3}{2}\sin(90 - i_B)$

$\therefore \quad \tan i_B = \frac{9}{8} \Rightarrow \sin\alpha = \frac{4}{3}\sin i_B$



$\Rightarrow \sin\alpha = \frac{4}{3}\times\frac{9}{\sqrt{145}} = \frac{12}{\sqrt{145}}$

13. In a spectrometer the smallest main scale division is $\frac{1}{3}$ of a degree. The total number of divisions on the vernier scale attached to the main scale is 60 which coincide with the 59 divisions of the main circular scale. The least count of the spectrometer is :-

(a) 20' (b) 20" (c) 30" (d) 30'

Ans. (b)

Sol. $\therefore$ 60 VSD = 59 MSD

$\therefore$ 1 VSD = $\frac{59}{60}$MSD

$\therefore$ 1 least count

= 1 MSD – 1 VSD

$= \frac{1}{60}$MSD

$= \frac{1}{60}\left(\frac{1^\circ}{3}\right) = 20''$

14. White light is used to illuminate two slits in Young's double slit experiment. Separation between the two slits is b and the screen is at a distance D(>>b) from the plane of slits. The wavelength missing at a point on the screen directly in front of one of the slits is :-

(a) $\frac{2b^2}{3D}$ (b) $\frac{2b^2}{D}$ (c) $\frac{b^2}{3D}$ (d) $\frac{b^2}{2D}$

Ans. (c)

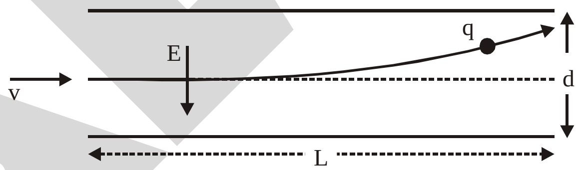
Sol. Path difference in front of one slit = $\frac{b^2}{2D}$

Let λ is the wavelength, whose minima coincides with this point, then

$$(2n+1)\frac{\lambda}{2} = \frac{b^2}{2D}$$

$$\lambda = \frac{b^2}{D(2n+1)}$$

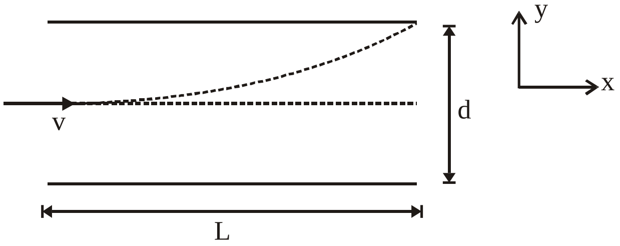
15. In an ink-jet printer, an droplet of mass m is given a negative charge q by a computer-controlled charging unit. The charged droplet then enters the region between two deflecting parallel plates of length L separated by distance d (see figure below) with a speed v. All over this region there exists a unifrom downward electric field E (in the plane of paper). Neglecting the gravitational force on the droplet, the maximum charge that can be given to this droplet, so that it does not hit any of the plates, is



(a) $\frac{mv^2L}{Ed^2}$ (b) $\frac{mv^2d}{EL^2}$ (c) $\frac{md}{Ev^2L^2}$ (d) $\frac{mv^2L^2}{Ed}$

Ans. (b)

Sol.



In limiting case drop will travel L distance along x axis while $\frac{d}{2}$ along y axis.

$$\therefore \frac{1}{2}\left(\frac{qE}{m}\right)t^2 = \frac{d}{2} \qquad \text{... (i)}$$

$$\& \ L = vt \qquad \text{... (ii)}$$

$$\therefore \frac{qE}{m}\cdot\frac{L^2}{v^2} = d$$

$$q = \frac{dmv^2}{EL^2}$$

16. A converging beam of light is pointing to P. Two observations are made with (i) a convex lens of focal length 20 cm and, (ii) a concave lens of focal length 16 cm placed in the path of the convergent beam at a distance 12 cm before the point P. It is observed that

(a) in both cases the images are real

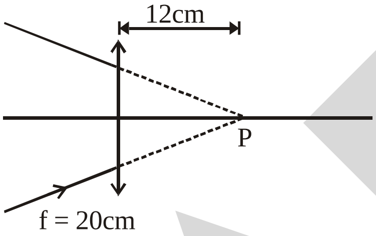
(b) in both cases the images are virtual

(c) for (i) the image is real and for (ii) the image is virtual

(d) for (i) the image is virtual and for (ii) the image is real

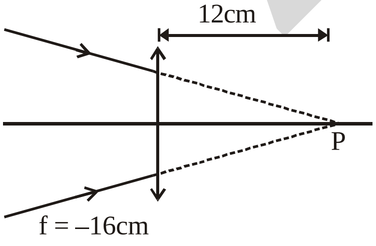
Ans. (a)

Sol.



(i) $\frac{1}{v} - \frac{1}{12} = \frac{1}{20}$

$v > 0$

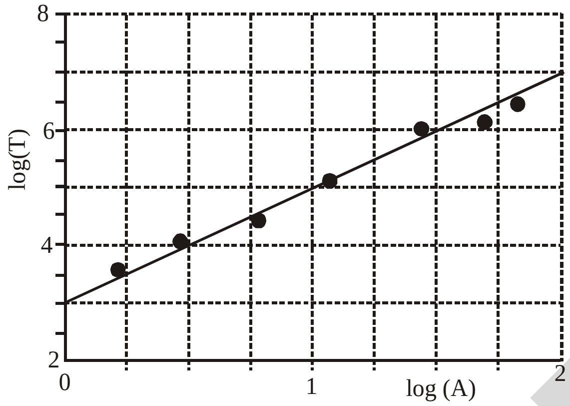


(ii) $\frac{1}{v} - \frac{1}{12} = -\frac{1}{16}$

$v > 0$

$\therefore$ both images are real

17. The log-log graph for a non-linear oscillator is shown below. Assuming the constants to have appropriate dimensions the relationship between time period (T) and the amplitude (A) can be expressed as :-



(a) $T = 1000\ A^2$ (b) $T = 4A^{1/2}$ (c) $T = 4A^2 + B$ (d) $T = 8A^3$

Ans. (a)

Sol. According to graph

$$\log(T) = \left(\frac{7-3}{2}\right)\log(A) + 3$$

$$\log(T) = 2\log A + 3$$

$$\log(T) = \log A^2 + \log 1000$$

$T = (1000\ A^2)$

18. In many situations the point source emitting a wave strats moving, through the medium, with velocity V greater than the wave velocity in that medium. In such a case when source velocity (V) > wave velocity (v), the wave front changes

(a) from spherical to plane (b) from spherical to conical

(c) from plane to spherical (d) from cylindrical to spherical

Ans. (b)

Sol. Theoretical

19. If the average mass of a smoke particle in an Indian kitchen is 3×10^{-17}kg, the rms speed of the smoke particles at 27ºC is approximately :

(a) 2 cm/sec (b) 2 m/sec (c) 2 km/sec (d) none of these

Ans. (a)

Sol. $v_{rms} = \sqrt{\frac{3RT}{M}} = 2$ cm/s

20. Two wires, made of same material, one thick and the other thin are joined to form one composite wire. The composite wire is subjected to the same tension throughout. A wave travels along the wire and passes the point where the two wires are joined. The quantity which changes at the joint are

(a) frequency only
(b) propagation speed only
(c) wavelength only
(d) both propagation speed and wavelength

Ans. (d)

Sol. Frequency is the property of material.

21. The frequency of the third overtone of a closed end organ pipe equals the frequency of the fifth harmonic of an open end organ pipe. Ignoring end correction, the ratio of their lengths $l_{open} : l_{close}$ is

(a) 10 : 7
(b) 10 : 9
(c) 2 : 1
(d) 7 : 10

Ans. (a)

Sol. $\frac{7v}{4\ell_{close}} = \frac{5v}{2\ell_{open}}$

$\frac{\ell_{open}}{\ell_{close}} = \frac{10}{7}$

22. Light of wavelength 640 nm falls on a plane diffraction grating with 12000 lines per inch. In the diffraction pattern on a screen kept at a distance of 12 cm from the grating, the distance of the second order maximum from the central maximum is

(a) 1.81 cm
(b) 2.41 cm
(c) 3.62 cm
(d) 7.25 cm

Ans. (d)

Sol. $\lambda = 640, d = \frac{1\text{ inch}}{12000} = \frac{2.54\text{cm}}{12000}$

for 2^{nd} order maxima

$d \sin\theta = 2\lambda$

$d\frac{y}{D} = 2\lambda \Rightarrow y = \frac{2D\lambda}{d}$

$y = \frac{2 \times 12 \times 10^{-2} \times 640 \times 10^{-9} \times 12000}{2.54 \times 10^{-2}}$

= 7.25 cm

23. If the force acting on a body is inversely proportional to its speed, the kinetic energy of the body varies with time t as

(a) t^0 (b) t^1 (c) t^2 (d) t^{-1}

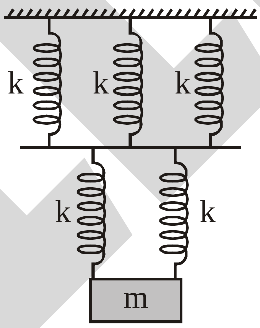
Ans. (b)

Sol. $F \propto \frac{1}{v} \Rightarrow F = \frac{k}{v} = \frac{k\partial t}{\partial x}$

$\int Fdx \Rightarrow \int kdt \Rightarrow W = kt$

$KE \propto t$

24. As shown in the figure, a block of mass m is hung from the ceiling by the system of springs consisting of two layers. The force constant of each of the springs is k. The frequency of vertical oscillations of the block is



(a) $\frac{1}{2\pi}\sqrt{\frac{k}{5m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{4k}{5m}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{5k}{6m}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

Ans. (d)

Sol. $\frac{1}{K_{eq}} = \frac{1}{3k} + \frac{1}{2k} \Rightarrow k_{eq} = \frac{6}{5}k$

$T = 2\pi\sqrt{\frac{5m}{6k}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

25. Two simple harmonic motions are given by $x_1 = a\sin\omega t + a\cos\omega t$ and $x_2 = a\sin\omega t + \frac{a}{\sqrt{3}}\cos\omega t$.

The ratio of the amplitudes of the first to the second and the phase difference between them respectively are

(a) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{12}$ (b) $\frac{\sqrt{3}}{2}$ and $\frac{\pi}{12}$ (c) $\frac{2}{\sqrt{3}}$ and $\frac{\pi}{12}$ (d) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{6}$

Ans. (a)

Sol. $x_1 = a\sin\omega t + a\cos\omega t$

$$= \sqrt{2}a\left(\frac{1}{\sqrt{2}}\sin\omega t + \cos\omega t\frac{1}{\sqrt{2}}\right)$$

$$= \sqrt{2}a\sin(\omega t + \pi/4)$$

$$x_2 = a\sin\omega t + \frac{a}{\sqrt{3}}\cos\omega t$$

$$= \frac{2a}{\sqrt{3}}\left(\frac{\sqrt{3}}{2}\sin\omega t + \frac{1}{2}\cos\omega t\right)$$

$$= \frac{2a}{\sqrt{3}}\sin\left(\omega t + \frac{\pi}{6}\right)$$

$$\frac{A_1}{A_2} = \frac{\sqrt{2}a\sqrt{3}}{2a} = \sqrt{\frac{3}{2}}$$

and $\phi_1 - \phi_2 = \frac{\pi}{12}$

26. A particle is projected from the ground with a velocity $\vec{v} = (3\hat{i} + 10\hat{j})ms^{-1}$. The maximum height attained and the range of the particle are respectively given by (use $g = 10\ m/s^2$)

(a) 5m and 6m (b) 3m and 10m (c) 6m and 5m (d) 3m and 5m

Ans. (a)

Sol. $\mu_m = \frac{u_y^2}{2g} = -\frac{20^2}{20} = 5m$

$$R = u_x\frac{2u_y}{g} = 3\times\frac{2\times10}{10} = 6m$$

27. A 20 cm long capillary tube stands vertically with lower end just in water. Water rises up to 5 cm. If the entire system is now kept on a freely falling platform, the length of the water column in the capillary tube will be

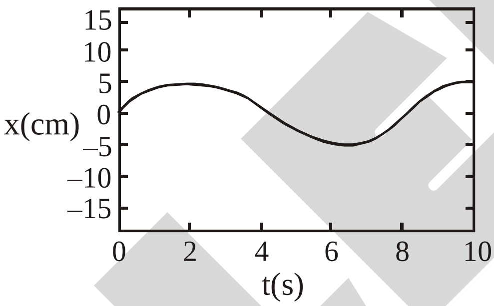
(a) 5 cm (b) 10 cm (c) Zero (d) 20 cm

Ans. (d)

Sol. $h = \frac{2T\cos\theta}{\rho g_{eff} r}$

$g_{off} = 0$ so $h \to \infty$ but water can't come out of tube, so h = length of tube = 20 cm

28. Position-time graph of a particle moving in a potential field is shown beside. If the mass of the particle is 1 kg its total energy is approximately



(a) 15.45×10^{-4} J (b) 30.78×10^{-4} J (c) 7.71×10^{-4} J (d) 3.85×10^{-4} J

Ans. (c)

Sol. $x = (5cm)\sin\left(\frac{2\pi}{8}t\right)$

$$TE = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2A^2$$

$$= \frac{1}{2}\times 1 \times \frac{\pi^2}{16}\times 25\times 10^{-4}$$

$= 7.71 \times 10^{-4}$ J

29. An observer stands on the platform at the front edge of the first bogie of a stationary train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

(a) 1.07 s (b) 0.98 s (c) 0.91 s (d) 0.81 s

Ans. (d)

Sol. Let length of first boggie is ℓ.

$$\ell = 0 + \frac{1}{2}at^2 = \frac{25}{2}a$$

So length of 10 boggies = 125 a

and length of 9 bogies = 25 × 4.5 a

So time taken by 10^{th} boggie to cross the man

$$= \sqrt{\frac{2 \times 125a}{a}} - \sqrt{\frac{2 \times 4.5 \times 25a}{a}}$$

$$= \sqrt{250} - \sqrt{225}$$

= 0.81 sec

30. The resistive force on an aeroplane flying in a horizontal plane is given by $F_f = kv^2$, where k is constant and v is the speed of the aeroplane. When the power output from the engine is P_0, the plane flies at a speed v_0. If the power output of the engine is doubled the aeroplane will fly at a speed of

(a) 1.12 v_0 (b) 1.26 v_0 (c) 1.41 v_0 (d) 2.82 v_0

Ans. (b)

Sol. $P = (kv^2)\cdot v$

$P = kv^3$

$v \propto P^{1/3}$

if P becomes double, v becomes $2^{1/3}$ times i.e. $v = 2^{1/3}v_0$.

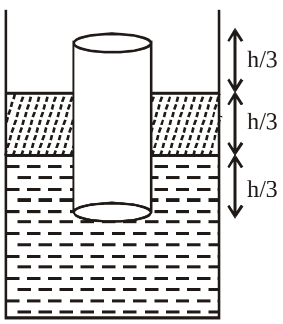
$= 1.26\ v_0$

31. A 3.0 cm thick layer of oil (density ρ_{oil} = 800 kg/m^3) floats on water (density ρ_w = 1000 kg/m^3) in a transparent glass beaker. A solid cylinder is observed floating vertically with $\frac{1}{3}$ of it in water and $\frac{1}{3}$ in the oil. Oil is gently poured into the beaker until the cylinder floats in oil only. The fraction of the solid cylinder in oil now is

(a) $\frac{3}{5}$ (b) $\frac{2}{3}$ (c) $\frac{3}{4}$ (d) $\frac{8}{9}$

Ans. (c)

Sol.



mg = B

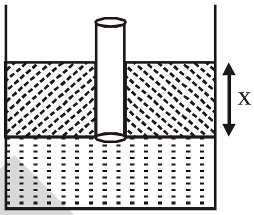
$$Ah\rho_S g = \frac{Ah\rho_w g}{3} + \frac{Ah\rho_0 g}{3}$$

$$\rho_S = \frac{\rho_\omega}{3} + \frac{\rho_S}{3} = 600$$

Now

mg = B

$Ah\rho_S g = Ax\rho_0 g$



$$\frac{\rho_S}{\rho_0} = \frac{x}{h}$$

$$\frac{x}{h} = \frac{600}{800} = \frac{3}{4}$$

32. A wedge of mass M rests on a horizontal frictionless surface. A block of mass m starts sliding down the rough inclined surface of the wedge to its bottom. During the course of motion, the centre of mass of the block and the wedge system

(a) does not move at all
(b) moves horizontally with constant speed
(c) moves horizontally with increasing speed
(d) moves vertically with increasing speed

Ans. (d)

Sol. $\Sigma F_{ext} = 0$ in horizontal
and $\Sigma F_{ext} \neq 0$ in vertical

33. A uniform circular disc rotating at a fixed angular velocity ω about an axis normal to its plane and passing through its centre has kinetic energy E. If the same disc rotates with an angular velocity 2ω about a parallel axis passing through the edge, its kinetic energy will be

(a) 2 E
(b) 4 E
(c) 10 E
(d) 12 E

Ans. (d)

Sol. $E = \frac{1}{2}I\omega^2$ where $I = \frac{mR^2}{2}$

Now $k' = \frac{1}{2}\left(\frac{3}{2}mR^2\right)(2\omega)^2$

$= \frac{1}{2}\left(\frac{mR^2}{2}\right)\omega^2(3 \times 4)$

= 12 E

34. Avalanche breakdown in a p-n junction primarily depends on the phenomenon of

(a) doping (b) collision (c) recombination (d) ionization

Ans. (b)

Sol. Conceptual

35. A source emits photons of energy 5 eV which are incident on a metallic sphere of work function 3.0 eV. The radius of the sphere is $r = 8 \times 10^{-3}$m. It is observed that after some time emission of photoelectrons from the metallic sphere is stopped. Charge on the sphere when the photoemission stops is.

(a) 1.77×10^{-16} C (b) 1.77×10^{-12} C

(c) 1.11×10^{-12} C (d) 1.11×10^{-10} C

Ans. (b)

Sol. Photoelectric effect stops when

$V_5 = V$

$$\left(\frac{h\nu - \phi}{e}\right) = \frac{kq}{r}$$

$$\frac{5eV - 3eV}{e} = \frac{kq}{r}$$

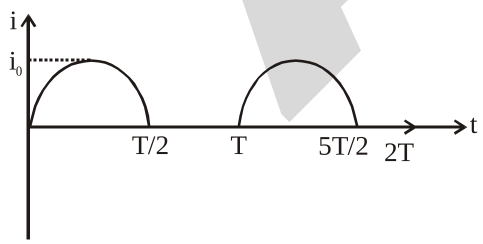
$$2 = \frac{kq}{r} \Rightarrow q = \frac{2 \times 8 \times 10^{-3}}{9 \times 10^{9}} = 1.77 \times 10^{-12}$$

36. The dc component of current in the output of a half - wave rectifier with peak value I_0 is

(a) zero (b) $\frac{I_0}{\pi}$ (c) $\frac{I_0}{2\pi}$ (d) $\frac{2I_0}{\pi}$

Ans. (b)

Sol.



$$i_{avg} = \frac{\int_0^{T/2} i_0 \sin\omega t dt + \int_{T/2}^{T} 0 dt}{T}$$

$$= \frac{i_0}{\pi}$$

37. In an experiment on photoelectric effect, the slope of straight line graph between the stopping potential and the frequency of incident radiation gives.

(a) Electron charge(e)
(b) Planck constant (h)
(c) $\frac{h}{e}$
(d) Work function (W)

Ans. (c)

Sol. $V_S = \frac{h\nu}{e} - \frac{\phi}{e}$

Slope = $\frac{h}{e}$

38. According to Bohr's theory the ionization energy of H atom is 13.6 eV. The energy needed to remove an electron from Helium ion (He^+) is

(a) 13.6 eV
(b) 16.8 eV
(c) 27.2 eV
(d) 54.4 eV

Ans. (d)

Sol. IE for Hc^+ = $Z^2(IE_H)$ = 4 × 13.6
= 54.4 eV

39. The phenomenon inverse to photo electric effect is

(a) Compton effect
(b) Pair production
(c) Raman effect
(d) Production of X-rays in Coolidge tube

Ans. (d)

Sol. Conceptual

40. A stationary hydrogen atom emits a photon of wavelength 1025Å. Its angular momentum changes by

(a) $\frac{h}{\pi}$
(b) $\frac{2h}{\pi}$
(c) $\frac{h}{2\pi}$
(d) $\frac{3h}{2\pi}$

Ans. (a)

Sol. λ is in U–V region so

$$\frac{1}{\lambda} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\frac{1}{1025 \times 10^{-10}} = 1.09 \times 10^7\left(1 - \frac{1}{n^2}\right)$$

$$\frac{10^3}{1025 \times 1.09} = 1 - \frac{1}{n^2}$$

$$\frac{1}{n^2} = 1 - \frac{10^3}{1025 \times 1.09} = 0.11$$

n = 3

So e^- makes transition from n = 3 to n = 1

$$\Delta L = (3-1)\frac{h}{2\pi} = \frac{h}{\pi}$$

41. A spherical capacitor is formed by two concentric metallic spherical shells. The capacitor is then charged so that the outer shell carries a positive charge and the inner shell carries an equal but negative charge Even if the capacitor is not connected to any circuit, the charge will eventually leak away due to a small electrical conductivity of the material between the shells. What is the character of the magnetic field produced by this leakage current ?

(a) Radially outwards from the inner shell to the outer shell

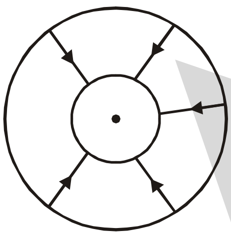
(b) Radially inwards from the outer shell to the inner shell

(c) Circular field lines between the shells and perpendicular to the radial direction.

(d) No magnetic field will be produced.

Ans. (d)

Sol.



Current will flow from outer sphere to inner sphere.

No magnetic field will be produced.

42. If a cell of constant emf produces the same amount of heat during the same time in two independent resistors R_1 and R_2 when they are separately connected across the terminals of the cell, one after the other. The internal resistance of the cell is

(a) $\frac{R_1 + R_2}{2}$ (b) $\frac{R_1 \sim R_2}{2}$ (c) $\frac{\sqrt{R_1^2 + R_2^2}}{2}$ (d) $\sqrt{R_1 R_2}$

Ans. (d)

Sol. Let e.m.f. of cell is ε & its internal resistance is r.

Rate of heat produced in R_1,

$$P_1 = \left(\frac{\varepsilon}{r+R_1}\right)^2 R_1$$

Rate of heat produced in R_2,

$$P_2 = \left(\frac{\varepsilon}{r+R_2}\right)^2 R_2$$

Given, $P_1 = P_2$

$$\left(\frac{\varepsilon}{r+R_1}\right)^2 R_1 = \left(\frac{\varepsilon}{r+R_1}\right)^2 R_2$$

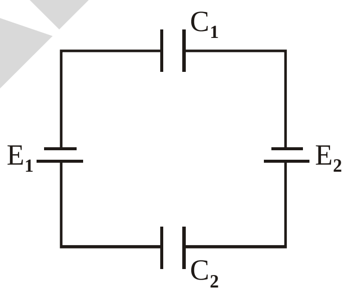
$$R_1(r + R_2)^2 = R_2(r + R_1)^2$$

$$\sqrt{R_1}\,(r + R_2) = \sqrt{R_2}\,(r + R_1)$$

$$r\left(\sqrt{R_1} - \sqrt{R_2}\right) = R_1\sqrt{R_2} - R_2\sqrt{R_1}$$

$$r = \frac{R_1\sqrt{R_2} - R_2\sqrt{R_1}}{\sqrt{R_1} - \sqrt{R_2}} = \sqrt{R_1R_2}\left(\frac{\sqrt{R_1} - \sqrt{R_2}}{\sqrt{R_1} - \sqrt{R_2}}\right) = \sqrt{R_1R_2}$$

43. In the circuit shown beside the charge on each capacitor is



(a) $(C_1 + C_2)(E_1 - E_2)$

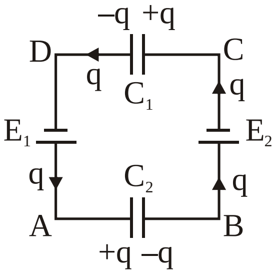
(b) $\frac{C_1C_2}{C_1 + C_2}(E_1 + E_2)$

(c) $\frac{C_1C_2}{C_1 + C_2}(E_1 - E_2)$

(d) $(C_1 - C_2)(E_1 + E_2)$

Ans. (c)

Sol.



Applying KVL in loop ABCDA

$$-\frac{q}{C_2}-E_2-\frac{q}{C_1}+E_1=0$$

$$q\left(\frac{1}{C_2}+\frac{1}{C_1}\right)=E_1-E_2$$

$$q=(E_1-E_2)\left(\frac{C_1C_2}{C_1+C_2}\right)$$

44. A stationary hydrogen atom emits photon corresponding to the first line (highest wave length) of Lyman series. If R is the Rydberg constant and M is the mass of the atom, the recoil velocity of the atom is

(a) $\frac{Rh}{4M}$ (b) $\frac{3Rh}{M}$ (c) $\frac{3Rh}{4M}$ (d) $\frac{Rh}{M}$

Ans. (c)

Sol. $\frac{1}{\lambda}=RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

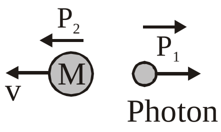
for first line of Lyman series

$n_1 = 1$ & $n_2 = 2$

$$\frac{1}{\lambda}=R(1)^2\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$$

$$\frac{1}{\lambda}=\frac{3R}{4}$$

Momentum of photon, $P_1=\frac{h}{\lambda}=\frac{3Rh}{4}$



By momentum conservation

$$P_2 = P_1$$

$$Mv = \frac{3Rh}{4}$$

$$v = \frac{3Rh}{4M}$$

45. Heat is absorbed or evolved when current flows in a conductor having a temperature gradient. This phenomenon is known as

(a) Joule effect (b) Peltier effect

(c) Seeback effect (d) Thomson effect

Ans. (d)

Sol. It is Thomson effect

46. A concave mirror has a radius of curvature R and forms the image of an object placed at a distance 1.5R from the pole of the mirror. An opaque disc of diameter half the aperture of the mirror is placed with the pole at the centre. As a result :

(a) the position of the image will be the same but its central half will disappear.

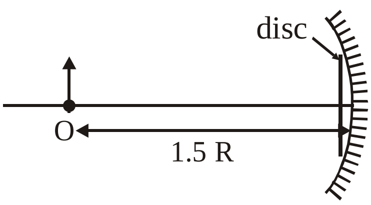
(b) the position of the image will be the same but its outer half will disappear.

(c) the complete image will be seen at the same position and it will be exactly identical with the initial image.

(d) the complete image will be seen at the same position but it will not be identical in all respect with the initial image.

Ans. (d)

Sol.



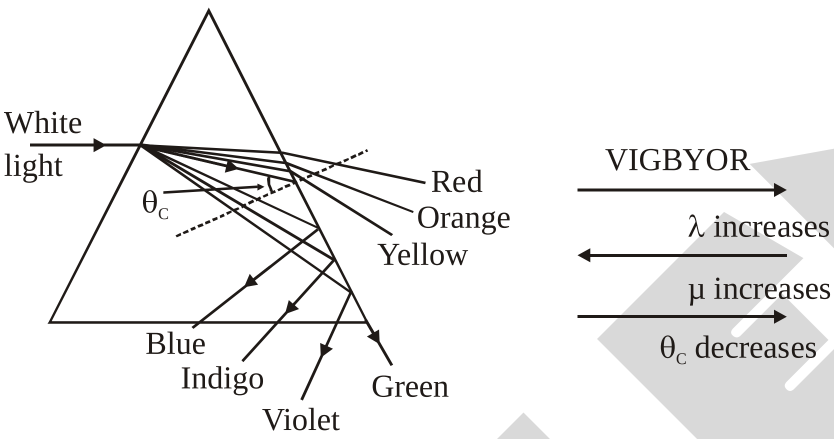
Disc will block few of the incident rays on the mirror. So intensity of image will decrease.

47. A ray of white light is made incident on the refracting surface of a prism such that after refraction at this surface, the green component falls on the second surface at its critical angle. The colours present in the emergent beam will be :

(a) violet, indigo and blue
(b) violet, indigo, blue, yellow, orange and red
(c) yellow, orange and red
(d) all colours

Ans. (c)

Sol.



$\sin\theta_C = \frac{1}{\mu}$

Cauchy's relation $\mu = A + \frac{B}{\lambda^2}$

The colours present in the emergent beam will be yellow, orange & red.

48. In a compound microscope, having tube-length 30 cm, the power of the objective and the eye-piece are 100 D and 10D respectively. Then the magnification produced by the microscope when the final image is at the least distance of distinct vision (25 cm) will be :

(a) 55 (b) 64 (c) 77 (d) 90

Ans. (c)

Sol. $f_0 = \frac{100}{P}$ cm

$= 1$ cm

$f_e = 10$ cm

For eye piece

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

$$\frac{1}{f_e}=\frac{1}{-25}+\frac{1}{u_e}$$

$$\frac{1}{10}=\frac{1}{-25}+\frac{1}{u_e}$$

$$\frac{1}{u_e}=\frac{1}{10}+\frac{1}{25}=\frac{5+2}{50}$$

$$u_e=\frac{50}{7}$$

$$L = v_0 + u_e$$

$$30=v_0+\frac{50}{7}$$

$$v_0=30-\frac{50}{7}=\frac{210-50}{7} \quad \Rightarrow \quad v_0=\frac{160}{7}$$

for objective

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

$$\frac{1}{u_0}=1-\frac{7}{160}=\frac{153}{160} \quad \Rightarrow \quad u_0=\frac{160}{153}$$

$$m_D=\frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)$$

$$=\frac{\frac{160}{7}}{\frac{160}{153}}\left(1+\frac{25}{10}\right)$$

$$=\frac{153}{7}\left(\frac{35}{10}\right)$$

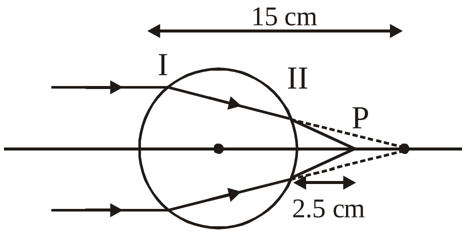
$$m_D \approx 77$$

49. Parallel rays are incident on a glass sphere of diameter 10 cm and having refractive index 1.5. The sphere converges these rays at a certain point. The distance of this point from the centre of the sphere will be :

(a) 2.5 cm (b) 5 cm (c) 7.5 cm (d) 12.5 cm

Ans. (c)

Sol.



for refraction at I surface :

$$\frac{1.5}{v} - \frac{1}{-\infty} = \frac{1.5-1}{5}$$

$v = 15$ cm

for refraction of II surface :

$$\frac{1}{v_2} - \frac{1.5}{5} = \frac{1-1.5}{-5}$$

$v_2 = 2.5$ cm

Distance of point P from centre

$= 5 + 2.5$

$= 7.5$ cm

50. A jet of water from 15 cm diameter nozzle of a fire hose can reach the maximum height of 25 m. The force exerted by the water jet on the hose is :

(a) 4.24 kN (b) 17.32 kN (c) 2.17 kN (d) 8.66 kN

Ans. (d)

Sol. $F = \rho A v^2 = 10^3 \times \left[\frac{\pi}{4} \times \left(15 \times 10^{-2}\right)^2\right] \times \left(\sqrt{2 \times 9.8 \times 25}\right)^2$

$= 8659$ N

$= 8.66$ kN

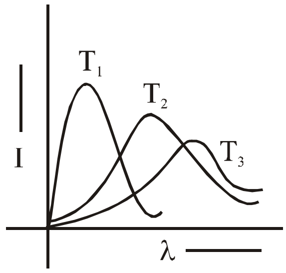
51. In an electromagnetic wave the phase difference between electric vector and magnetic vector is

(a) Zero (b) $\frac{\pi}{2}$ (c) π (d) $\frac{3\pi}{2}$

Ans. (a)

Sol. Phase difference = 0

52. Plots of intensity (I) of radiation emitted by a black body versus wavelength (λ) at three different temperatures T_1, T_2 and T_3 respectively are shown in figure. Choose the correct statement.



(a) $T_1 > T_2 > T_3$ necessarily (b) $T_3 > T_2 > T_1$ necessarily

(c) $T_2 = (T_1 + T_3) / 2$ necessarily (d) $T_2^2 = T_1T_3$ necessarily

Ans. (a)

Sol. Wein's law $\lambda_m T = b$

$$\Rightarrow T \propto \frac{1}{\lambda_m}$$

from graph $\lambda_1 < \lambda_2 < \lambda_3$

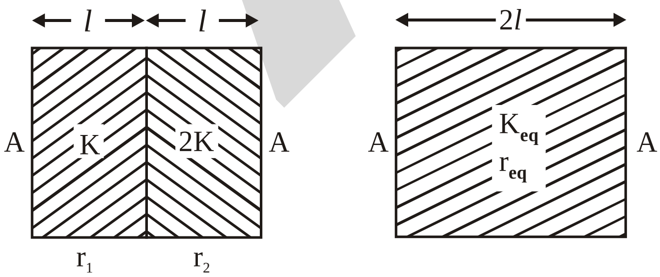
So, $T_1 > T_2 > T_3$

53. Consider a composite slab consisting of two different materials having equal thickness and equal area of cross section. The thermal conductivities are K and 2K respectively. The equivalent thermal conductivity of the composite slab is :

(a) $\frac{2K}{3}$ (b) $\sqrt{2}K$ (c) 3K (d) $\frac{4K}{3}$

Ans. (d)

Sol.



$r_{eq} = r_1 + r_2$

$$\frac{2\ell}{K_{eq}A} = \frac{\ell}{KA} + \frac{\ell}{2KA}$$

$$K_{eq} = \frac{4K}{3}$$

54. A large horizontal uniform disc can rotate freely about a rigid vertical axis passing through its centre O. A man stands at rest the edge of the disc at a point A. The mass of the disc is 22 times the mass of the man. The man starts moving along the edge of the disc. When he reaches A, after completing one rotation relative to the disc, the disc has turned through :

(a) 30° (b) 90° (c) 60° (d) 45°

Ans. **(a)**

Sol. Conserving angular momentum, we have

$I_1\theta_1 = I_2\theta_2$

$$mR^2(2\pi - \theta) = \frac{(22m)R^2}{2}(\theta)$$

Where θ is the angular displacement of the disc.

$2\pi - \theta = 11\ \theta$

$$\theta = \frac{\pi}{6} = 30°$$

55. Two factories are sounding their sirens at 400 Hz each. A man walks from one factory towards the other at a speed of 2 m/s. The velocity of sound is 320 m/s. The number of beats heard by the person in one second will be

(a) 6 (b) 5 (c) 4 (d) 2.5

Ans. **(b)**

Sol. $f_1 = 400\left(\frac{v - v_0}{v}\right)$ and $f_2 = 400\left(\frac{v + v_0}{v}\right)$

Number of beats heard per sec,

$\Delta f = f_2 - f_1$

$$= \frac{400}{v}\left[(v + v_0) - (v - v_0)\right]$$

$$= \frac{400}{v}[2v_0]$$

$$\Delta f = \frac{400}{320}[2 \times 2] = 5$$

56. The temperature of an isolated black body falls from T_1 to T_2 in time t. Then, t = Cx where x is :

(a) $\left(\frac{1}{T_2}-\frac{1}{T_1}\right)$ (b) $\left(\frac{1}{T_2^2}-\frac{1}{T_1^2}\right)$ (c) $\left(\frac{1}{T_2^3}-\frac{1}{T_1^3}\right)$ (d) $\left(\frac{1}{T_2^4}-\frac{1}{T_1^4}\right)$

Ans. (c)

Sol. Radiant power, $P \propto T^4$

$\Rightarrow$ Rate of fall in temperature = $\frac{dT}{dt} \propto T^4$

$$-\frac{dT}{dt} = kT^4$$

$$-\int_{T_1}^{T_2} \frac{dT}{T^4} = k\int_0^t dt$$

$$\frac{1}{3}\left[\frac{1}{T_2^3}-\frac{1}{T_1^3}\right] = kt$$

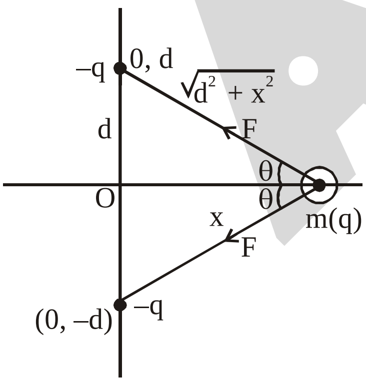
$$t = \frac{1}{3k}\left[\frac{1}{T_2^3}-\frac{1}{T_1^3}\right] \Rightarrow t = C\left[\frac{1}{T_2^3}-\frac{1}{T_1^3}\right]$$

57. Two charges –q and –q are placed at points (0, d) and (0, –d). A charge +q, free to move along X axis, will oscillate with a force proportional to

(a) $\frac{1}{x^2+d^2}$ (b) $\frac{1}{x^2}$ (c) $\frac{x}{(d^2+x^2)^{\frac{3}{2}}}$ (d) $\frac{1}{\sqrt{x^2+d^2}}$

Ans. (c)

Sol.



Net force towards origin is

$$F_{net} = 2F\cos\theta = \frac{2kqq}{\left(\sqrt{d^2+x^2}\right)^2}\frac{x}{\sqrt{d^2+x^2}}$$

$$F \propto \frac{x}{\left(d^2+x^2\right)^{3/2}}$$

58. The average translational kinetic energy of oxygen (M = 32) molecules at a certain temperature is 0.048 eV. The translational kinetic energy of nitrogen (M = 28) molecules at the same temperarture is (consider the two gases to be ideal) :

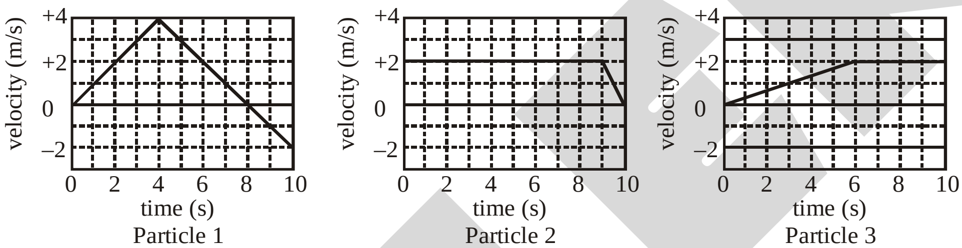
(a) 0.0015 eV (b) 0.042 eV (c) 0.048 eV (d) 0.768 eV

Ans. (c)

Sol. Average translational kinetic energy of a molecule = $\frac{3}{2}kT$.

It is same for all gases at same temperature.

59. In the following figures the velocity-time graphs for three particles 1, 2 and 3 are shown -



The magnitude of average acceleration of the three particles, over 10 s, bear the relationship

(a) $a_1 > a_2 > a_3$ (b) $a_2 > a_1 > a_3$ (c) $a_3 > a_2 > a_1$ (d) $a_1 = a_2 = a_3$

Ans. (d)

Sol. Average acc,

$$a_{avg} = \frac{|\Delta v|}{\Delta t}$$

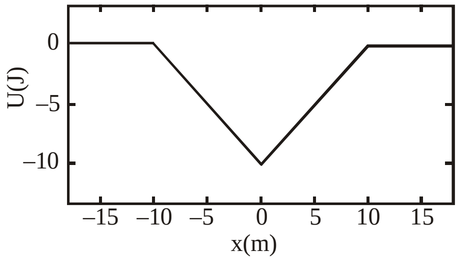
$$a_1 = \frac{|-2-0|}{10} = \frac{1}{5} m/s^2$$

$$a_2 = \frac{|0-2|}{10} = \frac{1}{5} m/s^2$$

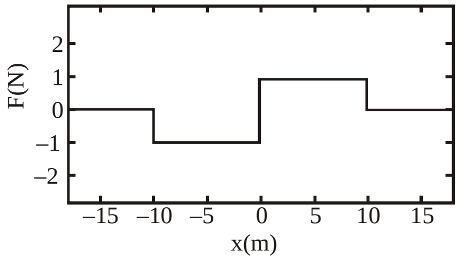
$$a_3 = \frac{|2-0|}{10} = \frac{1}{5} m/s^2$$

Hence $a_1 = a_2 = a_3$

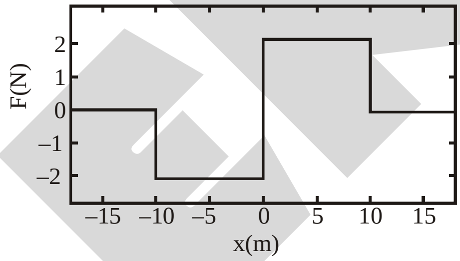
60. The potential energy (U) of a particle moving in a potential field varies with its displacement (x) as shown below -



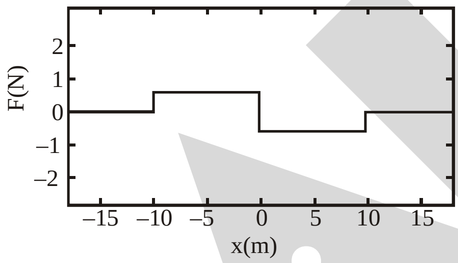
The variation of force F(x) acting on the particle as a function of x can be represented by



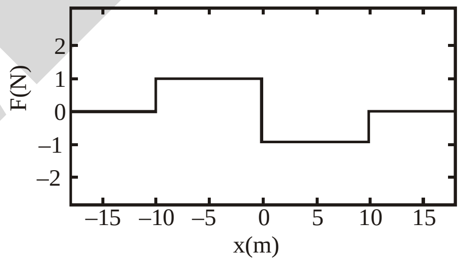
(Fig i)



(Fig ii)



(Fig iii)



(Fig iv)

(a) Fig (i) (b) Fig (ii) (c) Fig (iii) (d) Fig (iv)

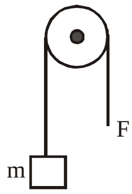
Ans. (d)

Sol. Force $F = -\frac{\partial u}{\partial x}$

= – slope of given graph

So, graph in fig(iv) is correct

61. A block of mass m = 10 kg is hanging over a frictionless light fixed pulley by an inextensible light rope. Initially the block is held at rest. The other end of the rope is now pulled by a constant force F in the vertically downward direction. The linear momentum of the block is seen to increase by 2 kgm/s in 1s (in the first second). Therefore,



(a) the tension in the rope is F

(b) the tension in the rope is 3N

(c) the work done by the tension on the block, in first second, is = 19.8 J

(d) the work done against the force of gravity, in first second, is = 9.8 J

Ans. **(a,d)**

Sol. (b) F – mg = ma

$\therefore$ a = 0.2

F = 98 + 2 = 100 N

(c) WD = $F\ell$ = $100 \times \frac{1}{2} \times 0.2 \times 1^2 = 10J$

(d) $WD_{a\text{-}g}$ = $mg\ell$ = $98 \times \frac{1}{2} \times 0.2 \times 1^2$

= 9.8 J

62. A ball of mass m_1 travels horizontally along the x-axis in the positive direction with an initial speed of v_0. It collides with another ball of mass m_2 that is originally at rest. After the collision, the ball of mass m_1 has velocity $(v_{1x}\hat{i} + v_{1y}\hat{j})$ and the ball of mass m_2 has velocity $(v_{2x}\hat{i} + v_{2y}\hat{j})$. Identify the correct relationship(s)

(a) $0 = m_1v_{1x} + m_2v_{2x}$

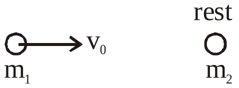
(b) $m_1v_0 = m_1v_{1y} + m_2v_{2y}$

(c) $0 = m_1v_{1y} + m_2v_{2y}$

(d) $m_1v_0 = m_1v_{1x} + m_2v_{2x}$

Ans. **(c,d)**

Sol.



Y : $0 = m_1v_{1y} + m_2v_{2y}$

X : $m_1v_0 = m_1v_{1x} + m_2v_{2x}$

63. In a real gas

(a) the force of attraction between the molecules depends upon intermolecular distance.

(b) internal energy depends only upon temperature

(c) internal energy is a function of both temperature and volume

(d) internal energy is a function of both temperature and pressure

Ans. (a,c,d)

Sol. E is function of P,V & T ; but on substituting V from

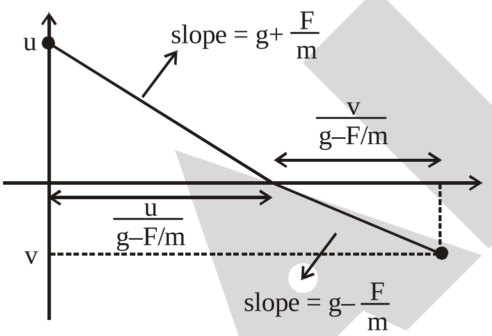
$\left(P+\frac{an^2}{V^2}\right)(V-nb)=nRT$; we get E dependent on P, V & T.

64. A particle of mass m is thrown vertically up with velocity u. Air exerts an opposing force of a constant magnitude F. The particle returns back to the point of projection with velocity v after attaining maximum height h, then

(a) $h=\frac{u^2}{2\left(g+\frac{F}{m}\right)}$ (b) $h=\frac{v^2}{2\left(g-\frac{F}{m}\right)}$ (c) $v=u\sqrt{\frac{\left(g-\frac{F}{m}\right)}{\left(g+\frac{F}{m}\right)}}$ (d) $v=u\sqrt{\frac{\left(g+\frac{F}{m}\right)}{\left(g-\frac{F}{m}\right)}}$

Ans. (a,b,c)

Sol.



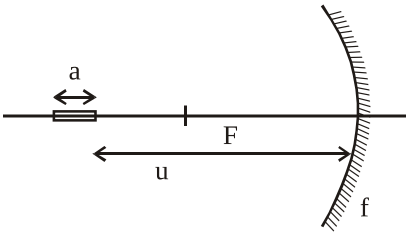
$$h=\frac{1}{2}\frac{u^2}{g+\frac{F}{m}}=\frac{1}{2}\frac{v^2}{g-\frac{F}{m}}$$

65. A pin of small length 'a' is placed along the axis of a concave mirror of focal length f, at the distance u (>f) from its pole. The length of its image is 'b'. If the same object is placed perpendicular to its axis at the same distance u and the length of its image is now 'c', then :-

(a) $b=a\frac{f^2}{(u-f)^2}$ (b) $c=\sqrt{ab}$ (c) $c=b\frac{u-f}{f}$ (d) $bc=\frac{a^2f^3}{(u-f)^3}$

Ans. (a,b,c,d)

Sol.



$$b = m^2 a = \left(\frac{f}{u-f}\right)^2 a$$

$$c = ma = \frac{f}{u-f} \cdot a$$

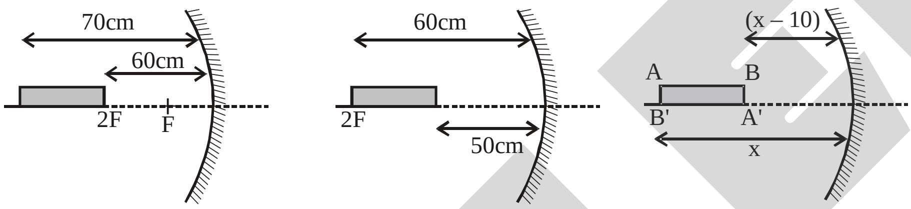
$$\frac{b}{c} = m \Rightarrow c = \frac{b}{m}$$

66. A thin rod of length 10 cm is placed along the axis of a concave mirror of focal length 30 cm in such a way that one end of the image coincides with one end of the object. The length of the image may be :-

(a) 7.5 cm (b) 12 cm (c) 15 cm (d) 10 cm

Ans. (a,c, d)

Sol.



Three cases are possible

(a) object is placed beyond 2F and one end touches the F.

(b) object is placed rightward 2F and one end touches 2F.

(c) Image of one end formed at other end of object.

case no I. $U_1 = -70$

$F_1 = -30$

$$V = \frac{UF}{U-F} = \frac{70 \times 30}{-70+30} = \frac{-2100}{40} = -52.5\text{cm}$$

length of image = 60 –52.5 = 7.5 cm

case no II. $U_1 = -50$

$F_1 = -30$

$$V = \frac{50 \times 30}{-50+30} = \frac{-1500}{20} = -75\text{cm}$$

length of image = 75 – 60 = 15 cm

Case-III $u = -x,\ v = -(x - 10)$

$$\frac{1}{-(x-10)} + \frac{1}{-x} = -\frac{1}{30}$$

$\Rightarrow (x + x - 10)30 = x(x - 10)$

$\Rightarrow 60x - 300 = x^2 - 10x$

$\Rightarrow x^2 - 70x + 300 = 0$

Since D > 0 for above equation and both roots are positive, therefor this situation is also possible $\ell' = 10$ cm

67. The mass of an electron can be expressed as :-

(a) 0.512 MeV (b) 8.19×10^{-14} J/c^2 (c) 9.1×10^{-31} kg (d) 0.00055 amu

where c is speed of light in vacuum

Ans. (b,c,d)

Sol. (a) option is dimensionally incorrect for mass.

(c) mass of $e^- = 9.1 \times 10^{-31}$ kg

(b) mass of $e^- = 9.1 \times 10^{-31}\ \text{kg} \times \dfrac{c^2}{c^2}$

$$= 9.1 \times 10^{-31}\ \text{kg} \times \frac{(3\times10^8)^2}{C^2} m^2/s^2$$

$$= 9.1 \times 10^{-31} \times 9 \times 10^{16} \frac{\text{kg}\,m^2}{s^2\,c^2}$$

$$= 8.19 \times 10^{-14}\ \text{J/C}^2$$

(d) mass of $e^- = \dfrac{8.19\times10^{-14}}{1.6\times10^{-19}} eV/c^2$

$$= \frac{8.19}{1.6}\times10^5\ \frac{eV}{c^2}\times\frac{931.5\times10^6}{931.5\times10^6}$$

$$= \frac{8.19\times10^5}{1.6\times931.5\times10^6} \times 931.5\times10^6 \frac{eV}{c^2}$$

$$= \frac{8.19\times10^5}{1.6\times931.5\times10^6}\ \text{amu}$$

$$= 0.00055\ \text{amu}$$

68. Select the correct statement(s), out of the following, about diffraction at N parallel slits :-

(a) There are (N-1) minima between each pair of principal maxima.

(b) There are (N-2) secondary maxima between each pair of principal maxima.

(c) Width of principal maximum is proportional to 1/N.

(d) The intensity at the principal maxima varies as N^2.

Ans. (a,b,c,d)

Sol. Conceptual

69. An electric dipole placed in a non-uniform electric field may experience :-

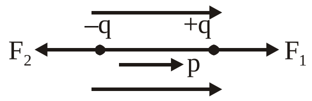
(a) no net force, no torque (b) a net force, but no torque.

(c) no net force, but a torque (d) a net force and a torque.

Ans. (a,b,c,d)

Sol. All four cases are possible it will depend on orientation of dipole in electric field and variation of electric field in space.

Example $\vec{E} = E_0 x\hat{j}$

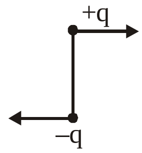


$\Rightarrow F_1 \neq F_2 \Rightarrow F_{Net} \neq 0$

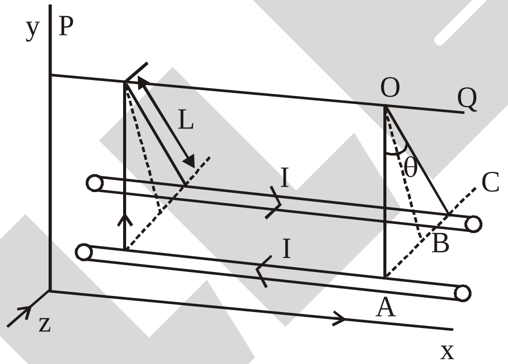
$\vec{T} = 0$ because $\vec{p}$ and $\vec{E}$ are parallel

$F_1 = F_2 \Rightarrow F_{net} = 0$

$\vec{T} \neq 0$ because $\vec{p}$ and $\vec{E}$ are $\perp$ to each other



70. Two long parallel wires carry currents of equal magnitude (I) but in opposite directions. These wires are suspended from fixed rod PQ by four chords of equal length L as shown. The mass per unit length of each wire is λ, the value of angle θ substended by two chords OA and OB, assuming it to be small, is :-



(a) $\theta = I\sqrt{\frac{\mu_0}{4\pi}\frac{\lambda}{gL}}$

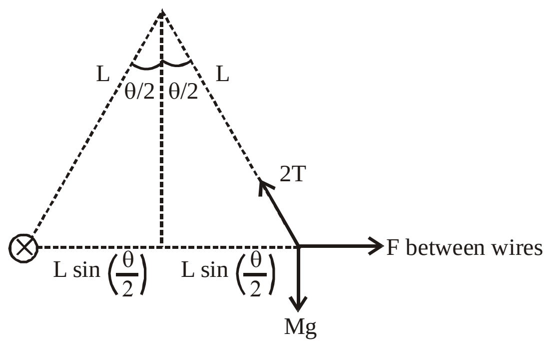
(b) $\theta = I\sqrt{\frac{\mu_0}{\pi}\frac{1}{\lambda gL}}$

(c) $\theta = I\sqrt{\frac{\mu_0}{4\pi}\frac{g}{\lambda L}}$

(d) $\theta = I\sqrt{\frac{\mu_0}{\pi}\frac{\lambda g}{L}}$

Ans. (b)

Sol. Drawing FBD of d length of each wire and taking side view.



$$\frac{2T\sin(\theta/2)}{2T\cos(\theta/2)} = \frac{\frac{\mu_0 I\, I}{2\pi(2L\sin\theta/2)}\times d}{(\lambda d).g}$$

$$\tan\frac{\theta}{2} = \frac{\mu_0 I^2}{4\pi L\sin\left(\frac{\theta}{2}\right)\lambda g}$$

$$\sin(\theta/2)\tan(\theta/2) = \frac{\mu_0 I^2}{4\pi L\lambda g}$$

$$\frac{\theta^2}{4} = \frac{\mu_0 I^2}{4\pi L\lambda g} \qquad \because \theta \text{ is small } \sin\theta \simeq \tan\theta \simeq \theta$$

$$\Rightarrow \quad \theta = \sqrt{\frac{\mu_0 I^2}{\pi L\lambda g}} = I\sqrt{\frac{\mu_0}{\pi L\lambda g}}$$