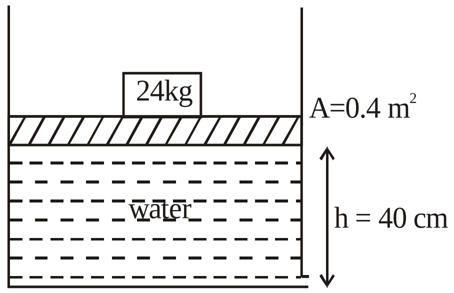
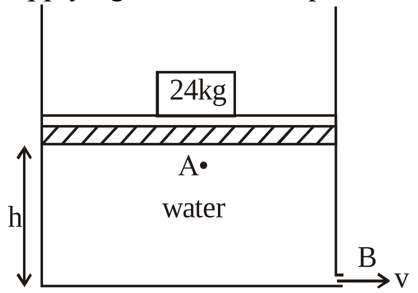
1. A cylindrical container contains water upto a height h = 40 cm enclosed by a light piston on top. A block of mass 24 kg is kept on the piston. Area of cross section of cylinder is 0.4 m^2. Find the speed at which water ejects from a small hole at bottom of cylinder at the green instant



Ans. 3.00

Sol. Applying Bernoulli's equation at A and B.



$$P_{atm} + \frac{mg}{A} + \rho gh + \frac{1}{2}\rho V^2 = P_{atm} + \frac{1}{2}\rho v^2$$

$V \to 0$

$$\frac{mg}{A} + \rho gh = \frac{1}{2}\rho v^2$$

$$\frac{24\times10}{0.4} + 1000\times10\times0.4 = \frac{100}{2}v^2$$

$v \simeq 3$ m/s.

2. A rod of mass m and length L is bent in semicircle then it's moment of inertia about an axis passing through the centre of semicircle & perpendicular to it's plane is:

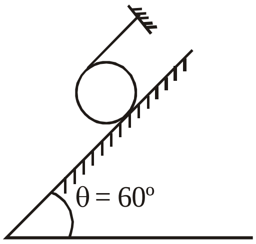
(1) $\frac{mL^2}{2\pi^2}$ (2) $\frac{mL^2}{\pi^2}$ (3) $\frac{2mL^2}{\pi^2}$ (4) $\frac{mL^2}{4\pi^2}$

Ans. (2)

Sol. $L = \pi R$, $R = \frac{L}{\pi}$

Moment of inertia = $mR^2 = \frac{mL^2}{\pi^2}$

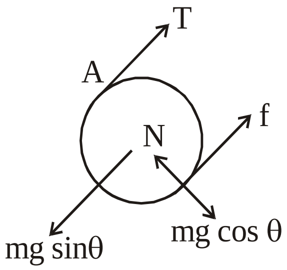
3. A solid cylinder of mass m and radius R is at rest on rough incline plane with $\mu_s = 0.4$ as shown in figure. If string is ideal, then friction force acting on solid cylinder is:



(1) $\sqrt{3}\frac{mg}{4}$ (2) $\frac{mg}{5}$ (3) $\frac{mg}{2}$ (4) $\frac{mg}{4}$

Ans. (1)

Sol.



$T_A = 0$, so mg sinθ × R = f × 2 R

$$f = \frac{mg\sin\theta}{2}$$

$$f = \sqrt{3}\frac{mg}{4}$$

4. (A) Electric monopoles doesn't exist whereas magnetic monopoles exist.

(B) Magnetic lines of solenoid at its ends and outside are not perfectly straight.

(C) Magnetic field lines of toroid are confined in it.

(D) Magnetic lines are not parallel inside bar magnet.

(E) Perfect Diamagnetic $\Rightarrow \chi = -1$

Which of the following statements are correct.

(1) A, B (2) A,C,E (3) B,C,E (4) B only

Ans. (3)

Sol. Theoretical.

5. A ball collides with another ball at rest elastically. Just after collision their velocity is equal in magnitude but opposite in direction find out ratio of their masses:

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

Ans. (1)

Sol. Using linear momentum conservation

$P_i = m_1u + m_2(0) = P_f = m_1v - m_2v$

$m_1u = (-m_1 + m_2)v$

$e = 1 = \dfrac{2v}{u} = 1$

$u = 2v$

$m_1 \times 2v = (m_2 - m_1)v$

$2m_1 = m_2 - m_1$

$3m_1 = m_2$

$\dfrac{m_1}{m_2} = \dfrac{1}{3}$

6. Kinetic energy of a proton and α particle is k_p and k_α respectively. Both are projected in same uniform magnetic field perpendicular to it if the ratio of radius of circular path is $\dfrac{2}{1}$ then find $\dfrac{k_p}{k_\alpha}$:

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

Ans. (1)

Sol. $R = \dfrac{\sqrt{2mK.E.}}{qB}$

$$\frac{R_p}{R_\alpha} = 2 = \sqrt{\frac{m \times k_p}{q^2}} \times \sqrt{\frac{4q^2}{4mk_\alpha}} \quad \Rightarrow \quad \frac{k_p}{k_\alpha} = 4$$

7. In an adiabatic process the fraction change in pressure is equal to : (adiabatic coefficient is γ)

(1) $-\dfrac{\gamma dv}{v}$ (2) $\dfrac{\gamma dv}{v}$ (3) $\dfrac{1}{\gamma}\dfrac{dv}{v}$ (4) $-\dfrac{1}{\gamma}\dfrac{dv}{v}$

Ans. (1)

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

$\ell nP + \gamma \ell nV = \text{constant}$

$$\frac{dP}{P} + \gamma\frac{dv}{v} = 0 \quad ; \qquad \frac{dP}{P} = -\gamma\frac{dv}{v}$$

8. A block of mass 4kg is moving with velocity 10 m/s collides with a spring of natural length 8m and spring constant 100 N/m. When it transfer all of its energy to spring then length (in m) of spring after compression is:

Ans. 2.00

Sol. $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$\frac{1}{2}4 \times 10^2 = \frac{1}{2} \times 100\ x^2$

x = 2m.

9. Which of the following represents SHM of time period π/ω.

(1) $\sin(\omega t) + \cos(\omega t)$

(2) $\sin^2(\omega t)$

(3) $\cos\left(\frac{3\pi}{4} - 2\omega t\right)$

(4) $\cos\omega t + \cos 2\omega t + \cos 3\omega t$

Ans. (3)

Sol. 2 and 3 option represent SHM of time period π/ω as angular frequency is 2ω.

If the above equations represent displacement from mean position then only 3 is correct but if they represent position then 2 and 3 both will be correct.

10. Proton can decay into neutron

(1) not possible since mass of proton is less than neutron

(2) possible only in nucleus

(3) always possible because decay is always with β^+ particle

(4) not possible because decay is always with β^+ particle

Ans. (2)

Sol. Theory (k-Capture)

11. A measurement is (7.5 ± 0.85), then percentage error is

Ans. 11

Sol. % error = $\frac{0.85}{7.5} \times 100 = 11.33$

12. An electromagnetic wave is travelling along y-axis. Which of the following can be it's electric field & magnetic field.

(1) E_x, B_y or B_x, E_z (2) E_y, B_x or B_y, E_x (3) E_x, B_z or E_z, B_x (4) B_y, E_z or E_y, B_z

Ans. (3)

Sol. $\hat{E} \times \hat{B} = \hat{C}$

i.e $\hat{E} \times \hat{B}$ points in the direction of propagation of EM wave.

13. In a series RLC circuit, capacitive reactance is 4Ω, inductive reactance is 10Ω & resistance is 6Ω then power factor of circuit is:

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

Ans. (2)

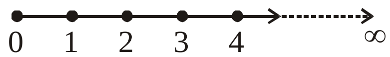
Sol. power factor

$$\text{Cos}\,\phi = \frac{R}{z}$$

$$= \frac{R}{\sqrt{R^2 + (x_L - x_C)^2}}$$

$$= \frac{6}{\sqrt{6^2 + (10-4)^2}} = \frac{1}{\sqrt{2}}$$

14. All charges of same magnitude ($1\mu C$) are placed on 1, 2, 4, 8, 16, ... ∞. Net force on charge 1C placed on origin is $x \times 10^3$ N then find the value of x.



Ans. 12.00

Sol. $F = \frac{kq_1q_2}{r_1^2} + \frac{kq_1q_2'}{r_2^2} + \frac{kq_1q_2''}{r_3^2} + ...$

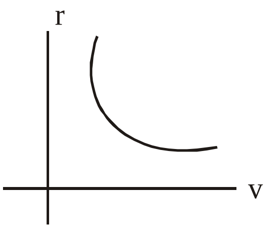
$$= 9 \times 10^9 \times 10^{-6}\left[1 + \left(\frac{1}{2}\right)^2 + \left(\frac{1}{2^2}\right)^2 + \left(\frac{1}{2^3}\right)^2 + ...\left(\frac{1}{2^\infty}\right)^2\right]$$

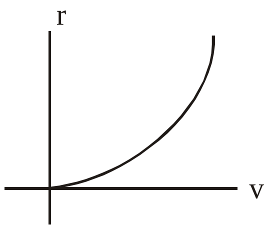
$$= 9 \times 10^9 \times 10^{-6}\left[\frac{1}{1-\frac{1}{4}}\right]$$

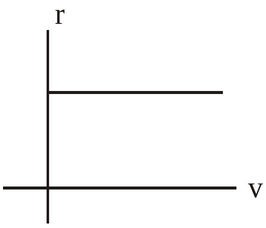
$$= 9 \times 10^3 \times \frac{4}{3}$$

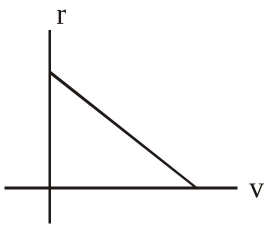
$$= 12 \times 10^3 \text{ N}$$

15. A particle is moving in circular track. Its potential energy is $U = -\frac{k}{r}$. Choose correct option for r –v graph.

(1) 

(2) 

(3) 

(4) 

Ans. (1)

Sol. $U = -\frac{k}{r}$

$F = -\frac{du}{dr} = \frac{k}{r^2}$

$\frac{1}{2}mv^2 = \frac{k}{r^2}$

$v = \sqrt{\frac{2k}{m}} \times \frac{1}{r}$

$y = \frac{C}{X}$

xy = C

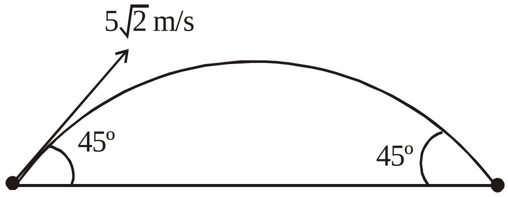
16. A planet is revolving around sun with angular momentum L and mass m. Then the areal velocity will be:

(1) $\frac{L}{m}$ (2) $\frac{L}{4m}$ (3) $\frac{L}{2m}$ (4) $\frac{2L}{m}$

Ans. (3)

Sol. Theoretical.

17. A particle of mass 5 gm is projected at an angle 45°. Then the magnitude of change in momentum between starting and end points is x × 10^{-2} kg m/s. Then the value of x. [g = 10 m/s^2]



Ans. 5.00

Sol. $\vec{P}_i = m(5\sqrt{2}\cos 45^\circ\,\hat{i} + 5\sqrt{2}\sin 45^\circ\,\hat{j})$

$\vec{P}_f = m(5\sqrt{2}\cos 45^\circ\,\hat{i} - 5\sqrt{2}\sin 45^\circ\,\hat{j})$

$\Delta\vec{P} = \vec{P}_f - \vec{P}_i = -2m \times 5\sqrt{2} \times \frac{1}{\sqrt{2}}\,\hat{j}$

$= -10 \times 5 \times 10^{-3}$ kg m/s

$\left|\overrightarrow{\Delta P}\right| = 5 \times 10^{-2}$ kg m/s

18. Find out time for LR current growth circuit at which energy stored in inductor is 25% of steady-state.

(1) $\frac{L}{R}\ell n2$ (2) $\frac{R}{L}\ell n2$ (3) $\frac{R}{L}\ell n4$ (4) $\frac{L}{R}\ell n3$

Ans. (1)

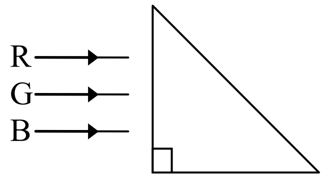
Sol. $U = \frac{1}{2}LI^2$

$\frac{1}{2}LI^2 = \frac{1}{4}LI_0^2$

$I = \frac{I_0}{2} = I_0(1 - e^{-t/\tau})$

$t = I\ell n2 = \frac{L}{R}\ell n2$

19. Three rays red, green and blue with refractive index $\mu_R = 1.23$, $\mu_G = 1.42$ $\mu_B = 1.47$ respectively. All rays incident on right angle prism as shown in figure, then which option is correct :



(1) Only red ray emerges from the prism
(2) red and green both emerges from the prism
(3) all rays emerges from the prism
(4) green and blue ray emerges from the prism

Ans. (1)

Sol. For T.IR

$i = 450$

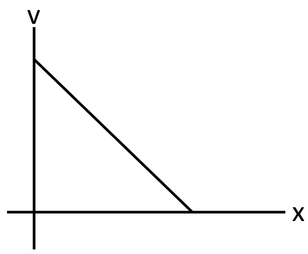
$i > C$ $\qquad\qquad$ $n > \sqrt{2}$

$45° > C$ $\qquad\qquad$ $n > 1.414$

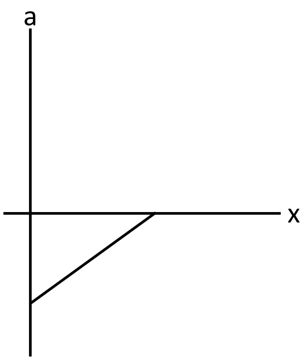
$\frac{1}{\sqrt{2}} > \frac{1}{n}$

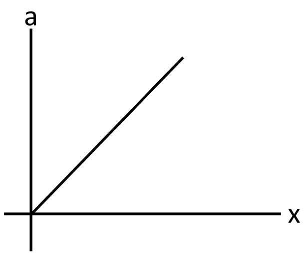
So only red ray will come out.

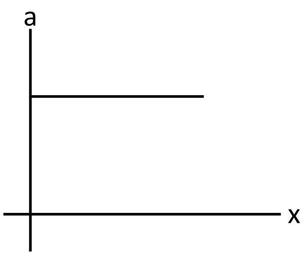
20. Velocity v/s displacement graph of a particle is shown in figure.

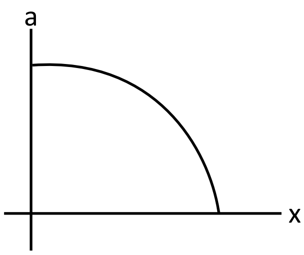


Correct a-x graph will be

(1) 

(2) 

(3) 

(4) 

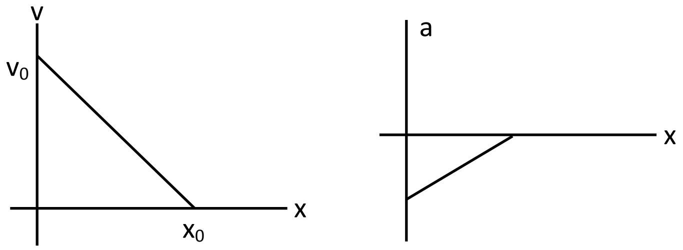
Ans. (1)

Sol. $\frac{v}{v_0}+\frac{x}{x_0}=1$

$\frac{a}{v_0}=-\frac{v_0}{x_0}v$

$\frac{a}{v_0}=-\frac{v_0^2}{x_0}\left(1-\frac{x}{x_0}\right)$

$a = -\frac{v_0^3}{x_0}\left(1-\frac{x}{x_0}\right)$



21. One antenna is placed at height 20m. Now it is placed 5m above the ground level. Change in range in later case is n% with respect to case 1. Find n.

Ans. 100.00

Sol. % change = $\left(\frac{\sqrt{2\times 20R}-\sqrt{2\times 5R}}{\sqrt{2\times 5R}}\right)\times 100$

= 100%

n = 100

22. The correct reaction between α and β is :

(1) $\alpha=\frac{\beta}{\beta+1}$ (2) $\beta=\frac{\alpha}{\alpha+1}$ (3) $\beta=\frac{\alpha}{\alpha-1}$ (4) $\alpha=\frac{\beta}{\beta-1}$

Ans. (1)

Sol. $\alpha=\frac{I_C}{I_E}$, $\beta=\frac{I_C}{I_B}$

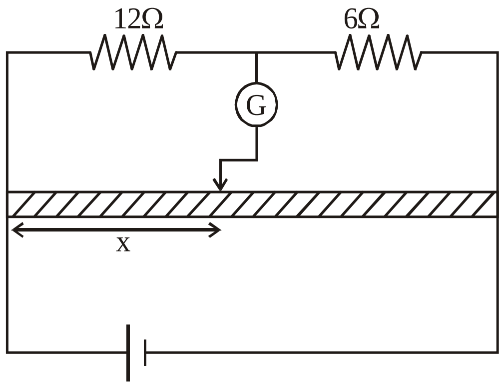
$I_E = I_B + I_C$

$\frac{I_E}{I_C}=\frac{I_B}{I_C}+1$

$\frac{1}{\alpha}=\frac{1}{\beta}+1$

$\alpha=\frac{\beta}{1+\beta}$

23. Total length of wire is 72 cm then find x (in cm) for zero deflection in galvanometer.



Ans. 48.00

Sol. $\frac{12}{x} = \frac{6}{(72-x)}$

$12 \times 72 - 12x = 6x$

$x = \frac{12 \times 72}{18}$

$x = 48$ cm

24. If we use proton instead of electron in an electron microscope. Then its resolving power will change by a factor of $(m_p = 1837\ m_e)$

(1) $\frac{1}{1837}$ (2) 1837 (3) $\sqrt{1837}$ (4) does not change

Ans. (3)

Sol. $RP \propto \frac{1}{\lambda}$

$\lambda \propto \frac{1}{\sqrt{m}}$

25. The ratio of rms speed and average speed of an ideal gas at 300 k temperature is:

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

Ans. (1)

Sol. $v_{RMS} = \sqrt{\frac{3RT}{M}}$

& $v_{avg} = \sqrt{\frac{8RT}{\pi M}}$

$\therefore \frac{v_{RMS}}{v_{avg}} = \sqrt{\frac{3\pi}{8}}$

26. Find duration of a day for a person at equator experiencing weightlessness condition.

[R_e = 6400 km]

(1) 1600 min (2) 84 min (3) No change (4) 120 min

Ans. (2)

Sol. effective gravity at

equator $g_{eff} = (g - R_e\omega^2) = 0$

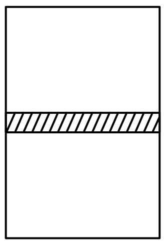
$\omega = \sqrt{\dfrac{g}{R_e}}$

so time period

$T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{R_e}{g}} = 84.6$ min

≈ 84

27. Two identical gases are enclosed in a chamber separated by a piston. If their entropies are S_1 and S_2 respectively then find entropy of the system after piston is removed



(1) $S_1 - S_2$ (2) S_1S_2 (3) $S_1 + S_2$ (4) $\dfrac{S_1}{S_2}$

Ans. (3)

Sol. $S_1 = \dfrac{f}{2}n_1R$ $S_2 = \dfrac{f}{2}n_2R$

$S = \dfrac{f}{2}(n_1 + n_2)R \Rightarrow S = S_1 + S_2$

28. Coming soon.

29. Coming soon.

30. Coming soon.