Solution

IIT - JAM – 2025 (Physics)

Full Length Test – 01

Ans. 1: (c)

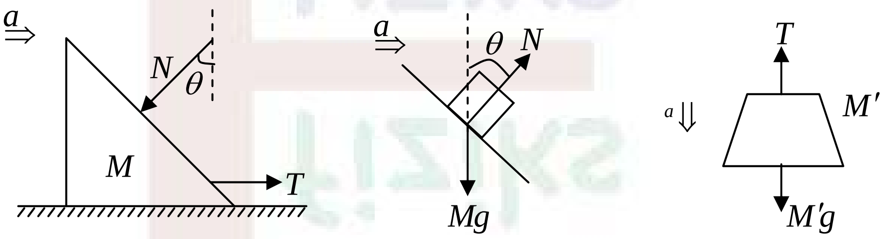
Solution: Potential inside $(\phi) = ar^2 + b \qquad \therefore E_r = -\frac{\delta\phi}{\delta r} = -2ar$

Electric field inside uniformly charged solid volume varies with $'r'$. So charge density is constant.

Thus $\therefore E_r = \frac{\rho r}{3\varepsilon_0} = -2ar \Rightarrow \rho = -6\varepsilon_0 a$

Ans. 2: (a)

Solution: $T - N\sin\theta = N\cos\theta = mg\,; M'g - T = M'a$



Solving for M', we get:

$$M' = \frac{M+m}{\cot\theta - 1}$$

Ans. 3: (c)

Solution: $t^2 u(t-3) = \left[(t-3)^2 + 6(t-3) + 9\right]u(t-3)$

$$= (t-3)^2 \cdot u(t-3) + 6(t-3)\cdot u(t-3) + 9u(t-3)$$

$$L\left[t^2 \cdot u(t-3)\right] = L\left[(t-3)^2 \cdot u(t-3)\right] + 6L\left[(t-3)\cdot u(t-3)\right] + 9L\left[u(t-3)\right]$$

$$= e^{-3s}\left[\frac{2}{s^3} + \frac{6}{s^2} + \frac{9}{s}\right]$$

A liter $L\left[t^2 u(t-3)\right] = e^{-3s}L(t+3)^2 = e^{-3s}L\left[t^2 + 6t + 9\right] = e^{-3s}\left[\frac{2}{s^3} + \frac{6}{s^2} + \frac{9}{s}\right]$

Ans. 4: (c)

Solution:

A	B	D	X
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

$$D = A\overline{B} + \overline{A}B,\quad X = \overline{A}B$$

Ans. 5: (b)

Solution: $dQ = dW$, since dQ is positive, so dW is positive and the gas will do positive work .

Ans. 6: (b)

Solution: Stopping potential is the negative potential which stops the emission of $(K.E)_{\max}$ electrons when applied.

$\therefore$ Stopping potential $= 4V$.

Ans. 7: (a)

Ans. 8: (c)

Ans. 9: (c)

Solution: The frequency of the combined motion is

$$\omega_a = \frac{\omega_1 + \omega_2}{2} = \frac{20\pi + 10\pi}{2} = 15\pi$$

$$f_a = \frac{\omega_a}{2\pi} = \frac{15\pi}{2\pi} = 7.5$$

Ans. 10: (b)

Ans. 11: (d)

Solution: The force on the two sides cancels.

At the bottom, $B = \frac{\mu_0 I_1}{2\pi a} \Rightarrow F = \left(\frac{\mu_0 I_1}{2\pi a}\right) I_2 a = \frac{\mu_0 I_1 I_2}{2\pi}(\text{up})$

At the top, $B = \frac{\mu_0 I_1}{2\pi(a+a)} \Rightarrow F = \frac{\mu_0 I_1 I_2 a}{4\pi a} \Rightarrow F = \frac{\mu_0 I_1 I_2}{4\pi}(\text{down})$

Thus Net Force $= \left(\frac{\mu_0 I_1 I_2}{2\pi} - \frac{\mu_0 I_1 I_2}{4\pi}\right) = \frac{\mu_0 I_1 I_2}{4\pi}(\text{up})$

Ans. 12: (a)

Solution: The initial angular momentum of the asteroid about the centre of the planet is $L = m\upsilon_0 d$.

At the turning point the velocity v of the asteroid will be perpendicular to the radial vector. Therefore the angular momentum $L' = mvR$ if the asteroid is to just graze the planet. Conservation of angular momentum requires that $L' = L$. Therefore

$$mvR = mv_0 d \text{ or } v = \frac{v_0 d}{R}$$

Energy conservation requires

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 - \frac{GMm}{R} \text{ or , } \quad v^2 = v_0^2 + \frac{2GM}{R}$$

Eliminating υ between (2) and (4) the minimum value of v_0 is obtained.

$$v_0 = \sqrt{\frac{2GMR}{d^2 - R^2}}.$$

Ans. 13: (a)

Solution: DC Analysis:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 - 0.7}{470k\Omega} = 24.04\,\mu A$$

$$I_E = (\beta + 1) I_B = 101 \times (24.04\,\mu A) = 2.43\,mA$$

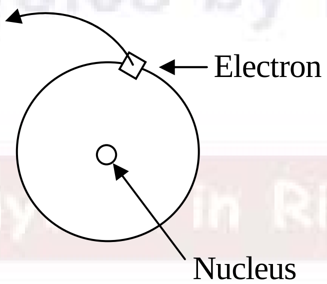
$$r_e = \frac{26\,mV}{I_E} = \frac{26\,mV}{2.43\,mA} = 10.7\,\Omega$$

AC Analysis:

$$r_o = \infty;\ A_v = -\frac{R_C}{r_e} = -\frac{2k\Omega}{10.7\Omega} \approx -187$$

Ans. 14: (c)

Solution:



The electrostatic force = centripetal force

i.e., $\frac{mv^2}{r} = \frac{Ze^2}{kr^2}$

$$\Rightarrow \quad mv^2 r = \frac{Ze^2}{k} \qquad \text{(i)}$$

By Bohr theory $mvr = n\hbar$ (ii)

Dividing equation (i) by, equation (ii), we get

$$v = \frac{Ze^2}{kn\hbar} \Rightarrow v = \frac{1}{n}\left(\frac{Ze^2}{k\hbar}\right) \Rightarrow v \propto \frac{1}{n} \Rightarrow \frac{v_1}{v_2} = \frac{n_2}{n_1} \Rightarrow v_2 = \frac{n_1}{n_2}v_1 \Rightarrow v_n = \frac{v_1}{n}$$

Ans. 15: (d)

Solution: $f(x)=\begin{cases}0 & \text{if} \quad -\pi<x<-\pi/2 \\ 1 & \text{if} \quad -\pi/2<x<\pi/2 \\ 0 & \text{if} \quad -\pi/2<x<\pi\end{cases}$ and $f(x+2\pi)=f(x)$

Let $f(x)=a_0+\sum_{n=1}^{\infty}(a_n\cos nx+b_n\sin nx)$

$$a_0=\frac{1}{2\pi}\int_{-\pi}^{\pi}f(x)dx=\frac{1}{2\pi}\left[\int_{-\pi}^{-\pi/2}(0)\,dx+\int_{-\pi/2}^{\pi/2}(1)\,dx+\int_{-\pi/2}^{\pi}(0)\,dx\right]=\frac{1}{2\pi}\pi=\frac{1}{2}$$

$$\because a_n=\frac{1}{\pi}\int_{-\pi}^{\pi}f(x)\cos nxdx$$

$$\Rightarrow a_n=\frac{1}{\pi}\left[\int_{-\pi}^{-\pi/2}(0)\cos nxdx+\int_{-\pi/2}^{\pi/2}(1)\cos nxdx+\int_{\pi/2}^{\pi}(0)\cos nxdx\right]$$

$$\Rightarrow a_n=\frac{1}{\pi}\left\{\frac{\sin nx}{n}\right\}_{-\pi/2}^{\pi/2}=\frac{1}{n\pi}\left\{\sin n\frac{\pi}{2}+\sin n\frac{\pi}{2}\right\}=\frac{2}{n\pi}\sin n\frac{\pi}{2}$$

$$\because b_n=\frac{1}{\pi}\int_{-\pi}^{\pi}f(x)\sin nxdx$$

$$\Rightarrow b_n=\frac{1}{\pi}\left[\int_{-\pi}^{-\pi/2}(0)\sin nxdx+\int_{-\pi/2}^{\pi/2}(1)\sin nxdx+\int_{-\pi/2}^{\pi}(0)\sin nxdx\right]\Rightarrow b_n=-\frac{1}{\pi}\left\{\frac{\cos nx}{n}\right\}_{-\pi/2}^{\pi/2}=0$$

Thus Fourier series is

$$f(x)=\frac{1}{2}+\frac{2}{\pi}\left[\frac{1}{1}\sin\frac{\pi}{2}\cos x+\frac{1}{2}\sin 2\frac{\pi}{2}\cos 2x+\frac{1}{3}\sin 3\frac{\pi}{2}\cos 3x+....\right]$$

$$f(x)=\frac{1}{2}+\frac{2}{\pi}\left[\cos x-\frac{1}{3}\cos 3x+\frac{1}{5}\cos 5x-+....\right]$$

Ans. 16: (d)

Solution: Characteristic time: $\tau=\frac{\varepsilon}{\sigma}=\frac{8.85\times10^{-12}}{10^{6}}=8.85\times10^{-18}$

Ans. 17: (d)

Solution: Group velocity is $v_g=d\omega/dk$. So, take the derivative of the quantity $\omega=\sqrt{c^2k^2+m^2}$ to get

$$v_g=d\omega/dk=\frac{c^2k}{\sqrt{c^2k^2+m^2}}$$

Use the above equation to test the choices:

(a) As $k\to0\Rightarrow v_g=0$, not infinity. The first condition doesn't work, no need to test the second (don't have to remember L'Hopital's rule).

(b) Wrong for the same reason as (a).

(c) As $k\to\infty, v_g\approx\frac{kc^2}{\sqrt{c^2k^2}}=c$, since $m<<(ck)^2$. So, v_g doesn't tend towards ∞. This choice is wrong.

(d) This is it. The conditions work (and it's the only choice left).

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Ans. 18: (c)

Solution: A diagonalised $= S^{-1} A\, S$ ….(i)

$S = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 0 & -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$, and finding S^{-1} and putting in (i), we get A diagonalized $= \begin{bmatrix} 2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 2 \end{bmatrix}$.

Ans. 19: (c)

Solution: $V_o = -\frac{R_1}{R_1} V_i + \left(1 + \frac{R_1}{R_1}\right) \frac{X_C}{R + X_C} V_i \Rightarrow \frac{V_o}{V_i} = \frac{1 - RCs}{1 + RCs}$ where $s = j\omega$.

Thus $\phi = -2\tan^{-1}(\omega RC)$.

Minimum value of $\phi = -\pi$ (at $\omega \to \infty$)

Maximum value of $\phi = 0$ (at $\omega = 0$)

Ans. 20: (a)

Solution: 16. Let $f_1 = u - x - y - z$, $f_2 = 2v - xyz$, and $f_3 = w - vx$.

$$\frac{\partial(f_1 f_2 f_3)}{\partial(x,y,z)} = \begin{vmatrix} \frac{\partial f_1}{\partial x} & \frac{\partial f_1}{\partial y} & \frac{\partial f_1}{\partial z} \\ \frac{\partial f_2}{\partial x} & \frac{\partial f_2}{\partial y} & \frac{\partial f_2}{\partial z} \\ \frac{\partial f_3}{\partial x} & \frac{\partial f_3}{\partial y} & \frac{\partial f_3}{\partial z} \end{vmatrix} = \begin{vmatrix} -1 & -1 & -1 \\ -yz & -xz & -xy \\ -v & 0 & 0 \end{vmatrix} = -v(xy - xz)$$

$$\frac{\partial(f_1, f_2, f_3)}{\partial(u,v,w)} = \begin{vmatrix} \frac{\partial f_1}{\partial u} & \frac{\partial f_1}{\partial v} & \frac{\partial f_1}{\partial w} \\ \frac{\partial f_2}{\partial u} & \frac{\partial f_2}{v} & \frac{\partial f_2}{\partial w} \\ \frac{\partial f_3}{\partial u} & \frac{\partial f_3}{\partial v} & \frac{\partial f_3}{\partial w} \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & -x & 1 \end{vmatrix} = 2$$

Hence $\frac{\partial(u,v,w)}{\partial(x,y,z)} = (-1)^3 \frac{\partial(f_1, f_2 f_3)}{\partial(x,y,z)} \Big/ \frac{\partial(f_1, f_2, f_3)}{\partial(u,v,w)} \Rightarrow \frac{\partial(u,v,\omega)}{\partial(x,y,z)} = \frac{v(xy - xz)}{2}$

at the point $x = 1, y = 2, z = 1,$ we have $v = \frac{1.2.1}{2} = 1$

Hence, $\left.\frac{\partial(u,v,\omega)}{\partial(x,y,)}\right|_{(1,2,1)} = \frac{1(1.2 - 1.1)}{2} = \frac{1}{2}$

Ans. 21: (d)

Solution: $1=\int_{-\infty}^{\infty}|\psi|^2 dx = A^2 = A^2\int_{-a}^{a}dx\left(1+2\cos\frac{\pi x}{a}+\frac{1}{2}\cos^2\frac{\pi x}{a}\right)$

$$=A^2\int_{-a}^{a}dx\left[\frac{3}{2}+2\cos\frac{\pi x}{a}+\frac{1}{2}\cos\frac{2\pi x}{a}\right] \text{ so } A=\frac{1}{\sqrt{3a}}$$

Ans. 22: (b)

Solution: Since $n_1=1,\ n_2=1.52$

Brewster angle $\theta_B=\tan^{-1}\left(\frac{n_2}{n_1}\right)=\tan^{-1}\left(\frac{1.52}{1}\right)=56.7^0$

Now $\theta_R=180-90-56.7=33.4^0$

Ans. 23: (a)

Solution: $\beta_T=-\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$

At a constant temperature, for a given mass of gas, $PV=$ constant, according to Boyle's law.

$\therefore PV=$ constant $\therefore PdV+VdP=0$

or $\frac{dV}{dP}=-\frac{V}{P}$ or $-\frac{1}{V}\left(\frac{dV}{dP}\right)=+\frac{1}{P}$ or $\beta_T=\frac{1}{P}$ or $\beta_T P=1$

Ans. 24: (a)

Solution: $T=2\pi\sqrt{\frac{l}{g}}$

The acceleration of lift is

$$a=\frac{dv}{dt}=\frac{d}{dt}\left(\frac{dy}{dt}\right)=\frac{d}{dt}\left[\left(1.5m/s^2\right)\left(2t\right)\right]=3m/s^2$$

The effective acceleration experienced by the pendulum is

$$T^1=2\pi\sqrt{\frac{1}{g+a}}$$

$$\therefore \frac{T^1}{T}=\sqrt{\frac{g}{g+a}}=\sqrt{\frac{10}{13}}$$

$$T^1=\sqrt{\frac{10}{13}}T$$

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Ans. 25: (b)

Solution: $\frac{dU}{dx}=0 \Rightarrow k\left(6x^2-10x+4\right)=0 \Rightarrow x=1, x=\frac{2}{3}$

$$\frac{d^2U}{dx^2}=k\left(12x-10\right)$$

For $x=1$, $\frac{d^2U}{dx^2}=2k>0$ and for $x=\frac{2}{3}$, $\frac{d^2U}{dx^2}=-4k<0$ So

$$\omega=\sqrt{\frac{2k}{m}} \Rightarrow \frac{2\pi}{T}=\sqrt{\frac{2k}{m}} \Rightarrow T=2\pi\sqrt{\frac{m}{2k}} \Rightarrow T=\pi\sqrt{\frac{2m}{k}}$$

Ans. 26: (d)

Solution: From first law of thermodynamics,

$TdS=dE+PdV$, $dE=TdS-PdV$, it is given $dV=0$

$$dE=TdS \Rightarrow dS=\frac{1}{T}dE$$

$$E=\frac{aT^2}{2}+\frac{bT^4}{4} \Rightarrow dE=aTdT+bT^3dT$$

$$dS=\frac{1}{T}\left(aTdT+bT^3dT\right)=adT+bT^2dT \Rightarrow S=aT+\frac{bT^3}{3}$$

Ans. 27: (b)

Solution 27: $y_p=\frac{1}{\left(D^2-4D+3\right)}3e^x\cos 2x=3e^x\frac{1}{\left(D+1\right)^2-4\left(D+1\right)+3}\cos 2x$

$$=3e^x\frac{1}{D^2-2D}\cos 2x \quad =3e^x\frac{1}{\left(-4\right)-2D}\cos 2x$$

$$=-\frac{3}{2}e^x\frac{D-2}{D^2-4}\cos 2x \quad =-\frac{3}{2}e^x\frac{1}{\left(-4\right)-4}\left(D-2\right)\cos 2x$$

$$=\frac{3}{16}e^x\left(-2\sin 2x-2\cos 2x\right) \quad \Rightarrow y_p=-\frac{3}{8}e^x\left(\sin 2x+\cos 2x\right)$$

The general solution of the corresponding homogeneous differential equation is

$$y_h=c_1e^x+c_2e^{3x}$$

Thus the general solution of the given nonhomogeneous equation is

$$y=y_h+y_p \Rightarrow y=c_1e^x+c_2e^{3x}-\frac{3}{8}e^x\left(\cos 2x+\sin 2x\right).$$

Ans. 28: (a)

Solution:

(a) $k_h = -k_e$ (correct)

If an electron is missing from an orbital of wave vector k_e the total wavevector of the system is $-ve$ and is attributed to the hole. $k_h + k_e = 0 \Rightarrow k_h = -k_e$

(b) $v_h = -v_e$ (Incorrect)

The velocity of the hole is equal to the velocity of the missing electron. Form the figure we see that $v_h = \frac{\partial E_h}{\partial k_h} = \frac{\partial E_e}{\partial k_e} = v_e \quad \Rightarrow v_h = v_e$

(c) $m_h = m_e$ (incorrect)

The effective mass is inversely proportional to the curvature $\frac{\partial^2 E}{\partial k^2}$ and for hole band this has the opposite sign to that for an electron in the valence band. Near the top of the valence band m_e is negative, so that m_h is positive

(d) $E_h = E_e$ (Incorrect)

If the band is symmetric. Then

$E_e(k_e) = E_e(-k_e) = -E_h(-k_h) = -E_h(k_h) \Rightarrow E_e = -E_h$

Ans. 29: (c)

Solution: Equating the volume, we have

$$8\left(\frac{4}{3}\pi r^3\right) = \frac{4}{3}\pi R^3 \text{ or } R = 2r$$

$$V_T \propto (\text{radius})^2$$

Radius has become two times. Therefore terminal velocity will become 4 times.

Ans. 30: (d)

Solution: $\frac{Nx_1}{Nx_2} = \frac{1}{e} = \frac{N_0 e^{-10\lambda t}}{N_0 e^{-\lambda t}}$

$$t = \frac{1}{9\lambda}$$

Ans. 31: (a), (b) and (c)

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Ans. 32: (b) and (d)

Solution: For orthogonal condition, scalar product

$(\psi_1, \psi_2) = 0$, so $1+2+3\alpha = 0 \Rightarrow \alpha = -1$

$$\psi_2 = \phi_0 - \phi_1 + \alpha\phi_2,\ \text{put}\ \alpha = -1, \langle H \rangle = \frac{\langle \psi_2 | H | \psi_2 \rangle}{\langle \psi_2 | \psi_2 \rangle} = \frac{\frac{\hbar\omega}{2} + \frac{3\hbar\omega}{2} + \frac{5\hbar\omega}{2}}{3} = \frac{3}{2}\hbar\omega$$

Ans. 33: (b) and (d)

Solution: Kinetic theory of gases are based on the following assumptions:

(i) All gases are made up of tiny elastic particles known as molecules.

(ii) The volume of the molecule is negligible.

(iii) The collision between the molecules is elastic.

(iv) They exert no force on each other.

Ans. 34: (a), (b), (c) and (d)

Solution: For the disc about its diameter $Mk^2 = \frac{MR^2}{4} \Rightarrow k = \frac{R}{2}$

For the disc about the tangent in its plane $Mk^2 = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2 \Rightarrow k = \frac{\sqrt{5}}{2}R$

For the thin rod about an axis through one end $MK^2 = \frac{ML^2}{3} \Rightarrow K = \frac{L}{\sqrt{3}}$

For a rectangular lamina about an axis through the centre and perpendicular to the rod

$$Mk^2 = \frac{M}{12}\left(l^2 + b^2\right) \Rightarrow k = \frac{1}{2}\sqrt{\frac{l^2 + b^2}{3}}.$$

Ans. 35: (a), (b) and (d)

Ans. 36: (a), (d)

Solution: Due to solenoid field is non zero in region 0 < r < R and non zero in region r >2R due to conductor.

Ans. 37: (a), (c)

Ans. 38: (a),(c) and (d)

Solution: $V_1 = \sqrt{2gh}$

$$V_2 = \sqrt{2g \times 4h} = 2v_1$$

$$t_1 = \sqrt{\frac{2h}{g}}, t_2 = \sqrt{\frac{2 \times 4h}{g}}$$

$$t_2 = 2t$$

$$R_1 = 2\sqrt{4 \times 4h}$$

$$R_2 = 2\sqrt{4h \times h}$$

Ans. 39: (b) and (c)

Solution:

(a) $y = a\cos(kx - \omega t)$

Wave speed $(v_p) = \frac{dx}{dt} = \frac{\omega}{k}$

Increasing ω also increases k as a result wave speed remain independent of frequency. Thus, this option is wrong.

(b) $v_p = \frac{\omega}{k}$

Thus v_p is also independent of amplitude 'a'. This is a correct option

(c) Power $p = \frac{1}{2}\mu\omega^2 A^2 v \quad \Rightarrow \quad P \propto A^2$

If 'A' changes by 2 than P increases by 4. This is a correct option

(d) wave frequency ω is independent of amplitude 'a'. This is a wrong option

Ans. 40: (a), (b)

Solution: $I = \frac{V_0}{\sqrt{\left(L\omega - \frac{1}{C\omega}\right) + R^2}}$

$f_R = \frac{1}{\sqrt{LC}} = 10^6\, rad\, s^{-1} \Rightarrow$ Resonance frequency

If $\omega \gg 10^6\, rad/s$, then circuit behaves as inductive circuit.

Ans. 41: 20

Solution: $f = \frac{qB}{2\pi m} \Rightarrow \frac{f'}{f_\alpha} = \frac{q'}{q_\alpha} \times \frac{m_\alpha}{m'} = \frac{q}{q} \times \frac{4m_p}{3m_p} = \frac{4}{3} \Rightarrow f' = 20\, MHz$

Ans. 42: 2

Solution: $t_2' - t_1' = 0 \Rightarrow \frac{t_2 - \frac{vx_2}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{t_1 - \frac{vx_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\left((t_2 - t_1) - \frac{v}{c^2}(x_2 - x_1)\right) = 0$

Dividing by $(t_2 - t_1)$ we get $1 - \frac{v}{c^2}\frac{(x_2 - x_1)}{(t_2 - t_1)} = 0 \Rightarrow \frac{(x_2 - x_1)}{(t_2 - t_1)} = \frac{c^2}{v} = 2c$

Ans. 43: (b)

Solution: $(8+0+2+1)+(0.5+0.25+0.125) = (11.875)_{10}$

Ans. 44: 1.86

Solution: Since, $E = 315\, MeV$ and $m_0 = 105\dfrac{MeV}{c^2}$.

$$E = mc^2 \Rightarrow E = \frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow 315 = \frac{105}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow v = 0.94\,c\,.$$

Now, $t = \dfrac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$, $t_0 = 2.2\mu s \Rightarrow t = \dfrac{2.2\times10^{-5}}{\sqrt{1-\frac{8}{9}}} = 6.6\,\mu s$

Now, the distance traversed by muon is $vt = 0.94\,c\times 6.6\times10^{-6} = 1.86\,km$.

Ans. 45: 10

Solution: $\varepsilon = -\dfrac{d\phi}{dt} = -(20t-50) = -10\,volt$.

Ans. 46: 1: 8

Solution: $N = \dfrac{1\times 8}{1} = 1$

Ans. 47: 19.8

Solution: $\dfrac{2\times3\pi^2\hbar^2}{2ma^2} = 2\times9.9\times10^{-17}\,J = 19.8\times10^{-17}\,J$

Ans. 48: 5

Solution: When $V_2 = 0$, $v_{01} = -V_1$ when $V_1 = 0$, $v_{02} = \left(1+\dfrac{R}{R}\right)\left(\dfrac{R_2}{R_1+R_2}\right)V_2$

Since $V_0 = -V_1 + \dfrac{V_2}{3} \Rightarrow 2\cdot\dfrac{R_2}{R_1+R_2} = \dfrac{1}{3} \Rightarrow \dfrac{R_1}{R_2} = 5$

Ans. 49: 2

Solution: $I_C = 4I_0$, $I_{INCO} = I_0 + I_0 = 2I_0$

Ratio $= \dfrac{I_C}{I_{INCO}} = 2$

Ans. 50: 6.0

Solution: $$\left|\frac{dN}{dt}\right| = \lambda N = \frac{0.693}{3.942\times10^{16}}\times\frac{70\times10^3}{40}\times\frac{3.29\times10^5}{100}\times6.022\times10^{23}$$

$= 6.0\times10^3$ disintegration / S

$= 6.0\times10^3\,Bq = 6\,KBq$

Ans. 51: 0.5

Solution: Magnetic dipole moment $M' = IA = \frac{Q}{T}\pi r^2 \Rightarrow \frac{Q}{2\pi T} \times 2\pi \times \pi r^2 = \frac{Q\omega r^2}{2} \quad \therefore \omega = \frac{2\pi}{T}$

Angular momentum $J = Mr^2\omega \Rightarrow \frac{M'}{J} = \frac{Q}{2M} = 0.5\left(\frac{Q}{M}\right)$

Ans. 52: 1.5

Solution:

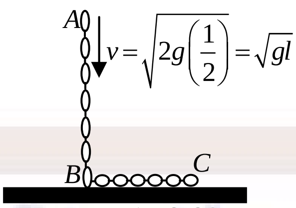

Fig.8.82

Force exerted by the chain on the table. It consists of two parts:

(1) Weight of the portion BC of the chain lying on the table.

$$W = \frac{mg}{2} \text{ (downwards)}$$

(2) Thrust force $F_t = \lambda v^2$

Here, $\lambda =$ mass per unit length of chain $= \frac{m}{l}$

$$v^2 = (\sqrt{gl})^2 = gl$$

$\therefore$ $F_t = \left(\frac{m}{l}\right)(gl) = mg$ (Downwards)

$\therefore$ Net force exerted by the chain on the table is

$$F = W + F_t = \frac{mg}{2} + mg = \frac{3}{2}mg \qquad \text{(Downwards)}$$

So, from Newton's third law the force exerted by the table on the chain will be $\frac{3}{2}mg$

(Vertical upwards).

Here, the thrust force (F_t) applied by the chain on the table will be vertically downwards, as $F_t = v_r\left(\frac{dm}{dt}\right)$ and in this expression v_r is downwards plus $\frac{dm}{dt}$ is positive. So, will be downwards.

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Ans. 53: 9.2

Solution: When $V=5V$ $\Rightarrow$ open circuit voltage $V_i=\frac{1000}{1500}\times 5=3.33<V_Z=10V$

$\Rightarrow V_L=V_i=3.33V \Rightarrow P_{L,\min}=\frac{V_i^2}{R_L}$.

When $V=20V$ $\Rightarrow$ open circuit voltage $V_i=\frac{1000}{1500}\times 20=13.33>V_Z=10V$

$\Rightarrow V_L=V_z=10V \Rightarrow P_{L,\max}=\frac{V_Z^2}{R_L}$

$$\Rightarrow \frac{P_{L,\max}}{P_{L,\min}}=\frac{V_Z^2}{V_i^2}=\left(\frac{10}{3.33}\right)^2=9.2$$

Ans. 54: 20

Solution: Total number of degeneracy

$g=$ (No. of energy state (n))$\times$(No. of degeneracy due to spin $(2s+1)$)

$n=3,\ s=\frac{1}{2},\qquad g=3\times(2.\frac{1}{2}+1)=6$

No. of particle $N=3$ so no. of ways ${}^{g}c_N={}^{6}c_3=20$

Ans. 55: 182

Solution: $I=\frac{V}{R}e^{-t/RC}=\frac{3}{10\times10^3}e^{-5/10\times10^3\times1000\times10^{-6}}=\frac{3}{10^4}e^{-5/10}=\frac{3}{\sqrt{e}\times10^4}=\frac{3}{1.65\times10^4}=182\,\mu A$

Ans. 56: 23

Solution: For no dispersion, $v_g=v$ i.e. $\frac{dv}{d\lambda}=0$

$$\therefore v^2=\frac{g\lambda}{2\pi}+\frac{2\pi\sigma}{\rho\lambda}$$

differentiating this $w.r.t$ λ and sifting

$\frac{dv}{d\lambda}=0$ and $\lambda=\lambda_0$ gives

$$\lambda_0=2\pi\sqrt{\frac{\sigma}{\rho g}}=2\pi\sqrt{\frac{7.2\times10^{-2}}{1000\times9.8}}$$

$$\lambda_0=1.70\times10^{-2}m$$

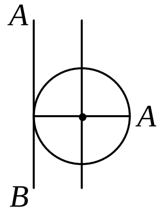
$$\therefore v_g=\left(\frac{g\lambda_0}{2\pi}+\frac{2\pi\sigma}{\rho\lambda_0}\right)^{1/2}$$

$$=\left(\frac{9.8\times1.7\times10^{-2}}{2\pi}+\frac{2\pi\times7.2\times10^{-2}}{1000\times1.7\times10^{-2}}\right)$$

$$=0.23\,m/\sec\quad=23\,cm/\sec$$

Ans. 57: 2000

Solution:



The moment of inertia of the disc about axis AB is

$$I_{AB} = I_{A'B'} + MR^2 = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2$$

The angular speed ω of the disc $= \frac{v}{R}$

Hence $K = \frac{1}{2}\times\frac{5}{4}MR^2\times\frac{v^2}{R^2} = \frac{1}{2}\times\frac{5}{4}\times 8\times 400 = 2000\ J$

Ans. 58: 2

Solution: $P = \frac{RT}{V-b}\exp\left(-\frac{a}{RTV}\right)$ critical point are point of inflection so, at critical points $\left(\frac{\partial P}{\partial V}\right)_T = 0$ and $\left(\frac{d^2P}{dV^2}\right)_T = 0$ (point of inflection)

So, $V_c = 2b$

Ans. 59: 2

Solution: Hence mass is loosing adiabatically the angular momentum is constant

$m_B \gg m_A$ $\frac{J^2}{m_A R_A^{\ 3}} = \frac{Gm_A m_B}{R_A^{\ 2}}$ so orbital radius R_A is proportional to $\frac{1}{m_A^2}$

Ans. 60: 10

Solution: $\Delta p = \frac{1}{2}\rho v^2$

$$\therefore v = \sqrt{\frac{2\Delta p}{\rho}} = \sqrt{\frac{2\times 0.5\times 10^5}{10^3}} = 10\,m/s$$
