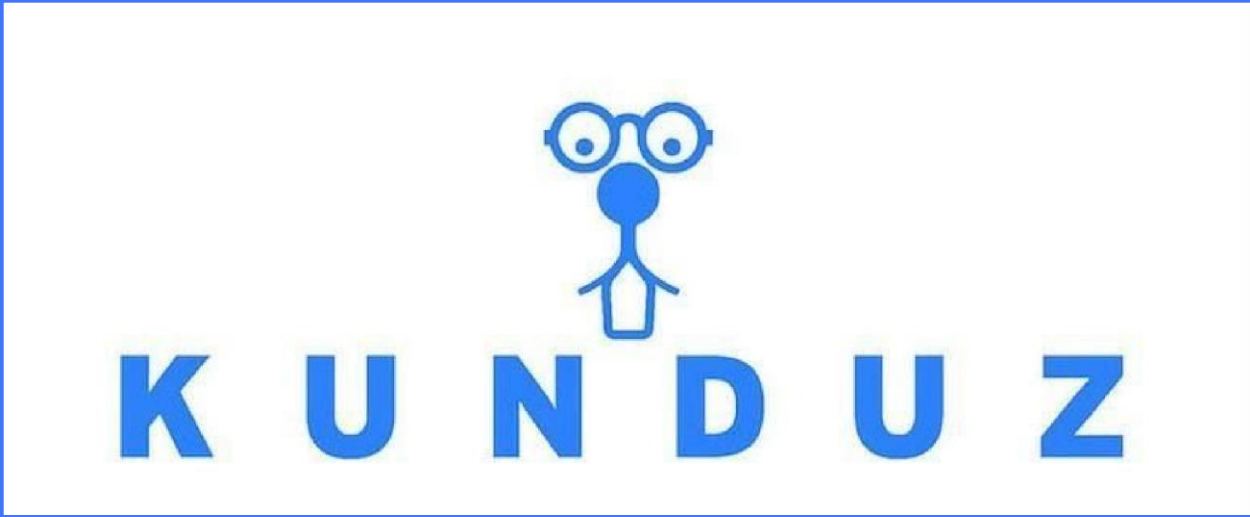


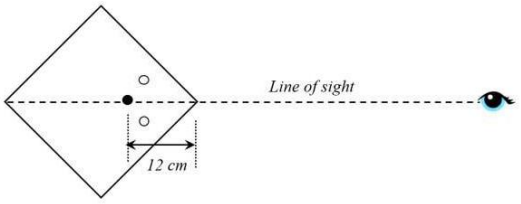
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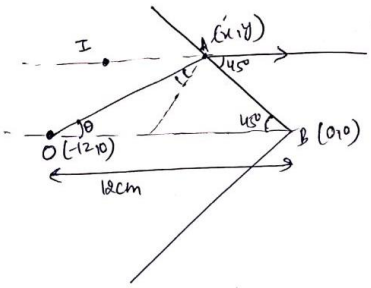
Question number	Question and Answers

1

Q.1 A large square container with thin transparent vertical walls and filled with water $\left(\text{refractive index } \frac{4}{3}\right)$ is kept on a horizontal table. A student holds a thin straight wire vertically inside the water 12 cm from one of its corners, as shown schematically in the figure. Looking at the wire from this corner, another student sees two images of the wire, located symmetrically on each side of the line of sight as shown. The separation (in cm) between these images is _____.



Q.1



A lot of rays will emerge from this wire, consider one which will become horizontal after deflecting from any edge

Using Snell's law

$$\frac{4}{3} \times \sin i = 1 \times \sin 45^\circ$$

$$\Rightarrow \boxed{\sin i = \frac{1 \times 3}{\sqrt{2}\ 4}} \qquad \tan i = \frac{3}{\sqrt{23}}$$

ΔAOB :— $\theta + 45^\circ + i + 90^\circ = 180^\circ$

So $\boxed{\theta = 45^\circ - i}$

eqn of line OA :— $\frac{(y-0)}{(x+12)} = m = \tan\theta$

$$y = (x+12)\tan(45^\circ - i) \quad \text{—— (1)}$$

$$\tan(45^\circ - i) = \frac{1 - \tan i}{1 + \tan i} = \frac{\sqrt{23} - 3}{\sqrt{23} + 3}$$

$y = -x$ for line AB —(2)

Solving (1) & (2)

$$y = \left(\frac{\sqrt{23} - 3}{\sqrt{23} + 3}\right)(12 - y)$$

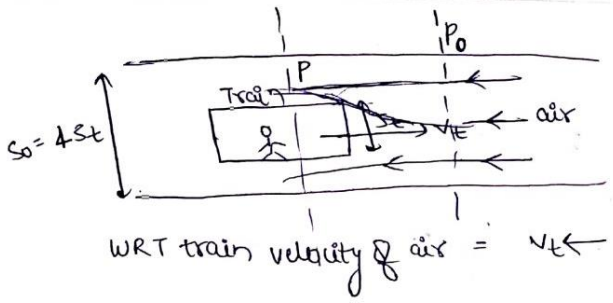
$$\Rightarrow y = \frac{12\left(\frac{\sqrt{23} - 3}{\sqrt{23} + 3}\right)}{\left(\frac{2\sqrt{23}}{\sqrt{23} + 3}\right)} = \frac{6(\sqrt{23} - 3)}{\sqrt{23}} \simeq 2$$

$\boxed{\text{separation} = 2y = 4 \text{ cm}}$

2

Q.2 A train with cross-sectional area S_t is moving with speed v_t inside a long tunnel of cross-sectional area S_0 ($S_0 = 4S_t$). Assume that almost all the air (density ρ) in front of the train flows back between its sides and the walls of the tunnel. Also, the air flow with respect to the train is steady and laminar. Take the ambient pressure and that inside the train to be p_0. If the pressure in the region between the sides of the train and the tunnel walls is p, *then* $p_0 - p = \frac{7}{2N}\rho v_t^2$. The value of N is _____.

Ans: 72



WRT train velocity of air = $V_t \leftarrow$

from Bernoulli's principle

$$a_1 v_1 = a_2 v_2$$

$$4 S_t V_t = 3 S_t V$$

$$\therefore V = \frac{4}{3} V_t$$

Also,

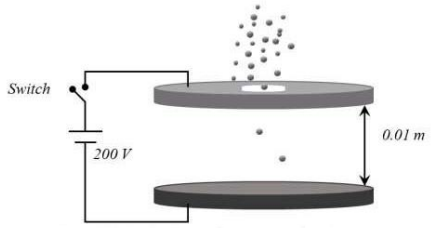
$$P_0 + \frac{1}{2}\rho V_t^2 = P + \frac{1}{2}\rho \frac{16}{9} V_t^2$$

$$\Rightarrow P_0 - P = \frac{1}{2}\frac{7\rho}{9} V_t^2$$

$$\therefore N = 9$$

3

Q.3 Two large circular discs separated by a distance of 0.01 m are connected to a battery via a switch as shown in the figure. Charged oil drops of density 900 kg m^{-3} are released through a tiny hole at the center of the top disc. Once some oil drops achieve terminal velocity, the switch is closed to apply a voltage of 200 V across the discs. As a result, an oil drop of radius 8×10^{-7} m stops moving vertically and floats between the discs. The number of electrons present in this oil drop is _____. (neglect the buoyancy force, take acceleration due to gravity = 10 ms^{-2} and charge on an electron (e) = 1.6×10^{-19} C)



Q3

$E = \frac{V}{d}$ (V = voltage applied = 200V)
d = distance b/w plates = 0.01 m

$E = \frac{200}{0.01} = 2 \times 10^4$ V/m

Terminal velocity is reached when net force = 0

So $qE = mg$ (on drops)

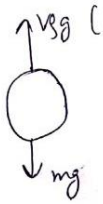
$n \times 1.6 \times 10^{-19} \times 2 \times 10^4 = \frac{4\pi}{3}(8 \times 10^{-7})^3 \times 900 \times 10$ $\left(\because mg = V\rho g\right)$

$\Rightarrow n \simeq 6$

4

Q.4 A hot air balloon is carrying some passengers, and a few sandbags of mass 1 kg each so that its total mass is 480 kg. Its effective volume giving the balloon its buoyancy is V. The balloon is floating at an equilibrium height of 100 m. When N number of sandbags are thrown out, the balloon rises to a new equilibrium height close to 150 m with its volume V remaining unchanged. If the variation of the density of air with height h from the ground is $\rho(h) = \rho_0 e^{-\frac{h}{h_0}}$, where $\rho_0 = 1.25\ \text{kg m}^{-3}$ and $h_0 = 6000$ m, the value of N is _____.

Q.4



At height 100m.

$\rho = \rho_0 e^{-\frac{100}{h_0}}$

$480 \times g = V \rho_0 e^{-\frac{100}{h_0}} g$ — ①

At height 150m $\rho = \rho_0 e^{-\frac{150}{h_0}}$

$(480 - N)g = V\rho_0 e^{-\frac{150}{h_0}} g$ — ②

① ÷ ② :—

$$\frac{480}{480-N} = \frac{e^{\frac{100}{h_0}}}{e^{-\frac{150}{h_0}}}$$

$$\frac{480}{480-N} = e^{\frac{50}{h_0}} = e^{\frac{50}{6000}}$$

$$\frac{480-N}{480} = 1 - \frac{N}{480} = e^{-\frac{50}{6000}}$$

(Using expansion $(e^{-x} = 1 - x + \dots)$)

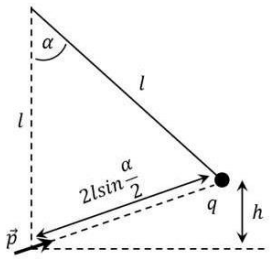
So, $\frac{N}{480} = \frac{50}{6000}$

$N = \frac{5 \times 480}{6000} = \frac{40}{10} = 4$

$N = 4$

5

Q.5 A point charge q of mass m is suspended vertically by a string of length l. A point dipole of dipole moment $\vec{p}$ is now brought towards q from infinity so that the charge moves away. The final equilibrium position of the system including the direction of the dipole, the angles and distances is shown in the figure below. If the work done in bringing the dipole to this position is $N \times (mgh)$, where g is the acceleration due to gravity, then the value of N is _____ . (Note that for three coplanar forces keeping a point mass in equilibrium, $\frac{F}{\sin\theta}$ is the same for all forces, where F is any one of the forces and θ is the angle between the other two forces)

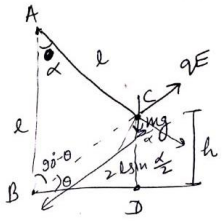


Q.5 Work done $= \Delta U$

Initial $U = U_i = 0$

$U_f = \frac{kqp}{\left(2l\sin\frac{\alpha}{2}\right)^2} + mgh$ — (1)

($\frac{kqp}{\left(2l\sin\frac{\alpha}{2}\right)^2}$ due to dipole; mgh due to gravity)



from ΔABC

$\alpha + 90 - \theta + 90 - \theta = 180°$

$\Rightarrow \boxed{\alpha = 2\theta}$

from ΔBCD $\quad \sin\theta = \frac{h}{2l\sin\frac{\alpha}{2}}$ $\quad \sin\theta = \frac{h}{2l\sin\theta}$

$\Rightarrow \sin\theta = \sqrt{\frac{h}{2l}}$ — (2)

Net force $= 0$ at eqm, so $mg\sin\alpha = qE\sin(\theta + 90° - \alpha)$

$mg\sin\alpha = q \times \frac{2kp}{\left(2l\sin\frac{\alpha}{2}\right)^3}\cos(\theta - \alpha)$

$mg\sin 2\theta = \frac{2kpq\cos\theta}{(2l\sin\theta)^3}$

$mg\, 2\sin\theta\cos\theta = \frac{2kpq\cos\theta}{(2l)^3\sin^3\theta}$

$mg\sin^4\theta = \frac{kpq}{8l^3}$ $\quad \sin\theta = \left(\frac{kpq}{8mgl^3}\right)^{1/4}$

from -(1)

$U_f = \frac{kpq}{4l^2\sin^2\theta} + mgh = \frac{8l^3 mg\sin^4\theta}{4l^2\sin^2\theta} + mgh$

$= 2l mg\sin^2\theta + mgh$

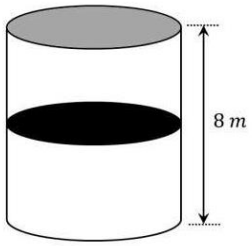
$= 2l mg\frac{h}{2l} + mgh$ (from 2)

$= 2mgh$

$W = \Delta U = 2mgh \Rightarrow \boxed{N = 2}$

6

Q.6 A thermally isolated cylindrical closed vessel of height 8 m is kept vertically. It is divided into two equal parts by a diathermic (perfect thermal conductor) frictionless partition of mass 8.3 kg. Thus the partition is held initially at a distance of 4 m from the top, as shown in the schematic figure below. Each of the two parts of the vessel contains 0.1 mole of an ideal gas at temperature 300 K. The partition is now released and moves without any gas leaking from one part of the vessel to the other. When equilibrium is reached, the distance of the partition from the top (in m) will be _____ (take the acceleration due to gravity = 10 ms^{-2} and the universal gas constant = 8.3 $J\,mol^{-1}K^{-1}$).

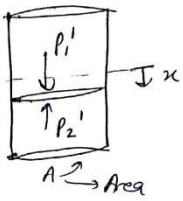


Sol Let say due to gravity, plate moves down by x.

Since temperature remains const at 300 K. (PV = constant)

$P_2\left(\frac{V_0}{2}\right) = P_2'\left(\frac{V_0}{2} - Ax\right)$ [for bottom container]

$P_1\left(\frac{V_0}{2}\right) = P_1'\left(\frac{V_0}{2} + Ax\right)$ (for upper)



And also net force = 0 at eqm so

$mg = (P_2' - P_1')A$

$mg = \left(\frac{P_2\left(\frac{V_0}{2}\right)}{\frac{V_0}{2} - Ax} - \frac{P_1\left(\frac{V_0}{2}\right)}{\frac{V_0}{2} + Ax}\right)A$

$P_1 = P_2$ as initially n, T, V all same. , $V_0 = A \times 8$

$mg = \frac{P_1 V_0}{2}\left(\frac{1}{\frac{V_0}{2} - Ax} - \frac{1}{\frac{V_0}{2} + Ax}\right)A$

$mg = \frac{P_1 V_0}{2} \frac{2Ax}{\left(\frac{V_0^2}{4} - A^2x^2\right)}$ $\Rightarrow$ $mg = \frac{P_1 V_0 Ax}{\left(\frac{V_0^2}{4} - A^2x^2\right)}$

$P_1 V_0 = nRT$ $n = 0.1$ $T = 300$

$8.3 \times 10 = 0.1 \times 8.3 \times 300 \times \left(\frac{Ax}{16A^2 - A^2x^2}\right)$

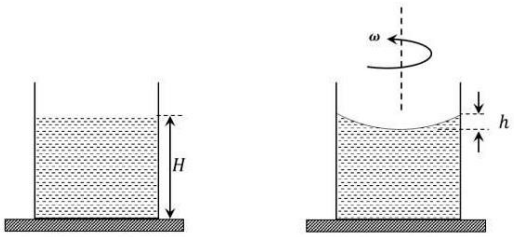
$1 = \frac{6x}{16 - x^2}$ $x^2 + 6x - 16 = 0$

$\Rightarrow x = 2$

distance = $4 + 2 = 6$ m

7

Q.7 A beaker of radius r is filled with water $\left(\text{refractive index } \frac{4}{3}\right)$ up to a height H as shown in the figure on the left. The beaker is kept on a horizontal table rotating with angular speed ω. This makes the water surface curved so that the difference in the height of water level at the center and at the circumference of the beaker is h ($h \ll H$, $h \ll r$), as shown in the figure on the right. Take this surface to be approximately spherical with a radius of curvature R. Which of the following is/are correct? (g is the acceleration due to gravity)



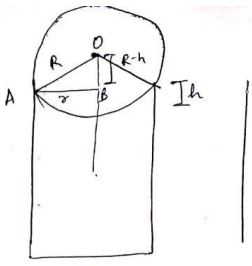
(A) $R = \frac{h^2+r^2}{2h}$

(B) $R = \frac{3r^2}{2h}$

(C) Apparent depth of the bottom of the beaker is close to $\frac{3H}{2}\left(1+\frac{\omega^2 H}{2g}\right)^{-1}$

(D) Apparent depth of the bottom of the beaker is close to $\frac{3H}{4}\left(1+\frac{\omega^2 H}{4g}\right)^{-1}$

Q.7



In $\triangle OAB$

$R^2 = r^2 + (R-h)^2 \Rightarrow 0 = r^2 + h^2 - 2hR$

$2hR = r^2 + h^2$

$\boxed{R = \frac{h^2+r^2}{2h}}$

Now, considering equation of surface

$y = y_0 + \frac{\omega^2 r^2}{2g}$ $\quad y - y_0 = h$

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

Now using: $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

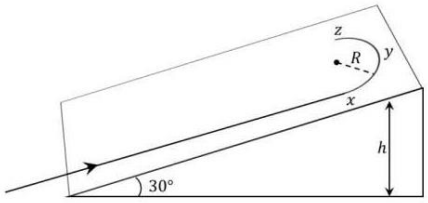
$\frac{1}{v} + \frac{4}{3(H-h)} = \frac{1-\frac{4}{3}}{-R}$

$\Rightarrow \frac{1}{v} = \frac{1}{3R} - \frac{4}{3H}$

$\Rightarrow \boxed{V = \frac{3H}{4}\left[1+\frac{\omega^2 H}{4g}\right]^{-1}}$ Ans

8

Q.8 A student skates up a ramp that makes an angle 30° with the horizontal. He/she starts (as shown in the figure) at the bottom of the ramp with speed v_0 and wants to turn around over a semicircular path xyz of radius R during which he/she reaches a maximum height h (at point y) from the ground as shown in the figure. Assume that the energy loss is negligible and the force required for this turn at the highest point is provided by his/her weight only. Then (g is the acceleration due to gravity)



(A) $v_0^2 - 2gh = \frac{1}{2}gR$

(B) $v_0^2 - 2gh = \frac{\sqrt{3}}{2}gR$

(C) the centripetal force required at points x and z is zero

(D) the centripetal force required is maximum at points x and z

Q.8

Applying energy conversion b/w starting point & point y.

$$\frac{1}{2}mv_0^2 = mgh + \frac{1}{2}mv_1^2$$

$$v_1^2 = v_0^2 - 2gh \quad \text{—— (1)}$$

As said in ques, centripetal at y is provided only by gravity

So $mg\sin 30^\circ = \frac{mv_1^2}{R}$

$$v_1^2 = \frac{gR}{2} \quad \text{—— (2)}$$

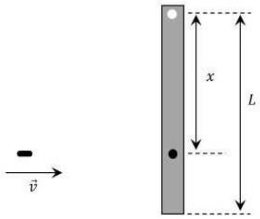
Putting in (1)

$$\boxed{\frac{gR}{2} = v_0^2 - 2gh}$$

At x & z, if we apply energy conversation separately between bottom point & these 2 points, we know x & z are at lower height than h, but are at same height, so velocity in both case would be more than y to compensate drop in potential energy. So req. $\frac{mv^2}{r}$ is more.

9

Q.9 A rod of mass m and length L, pivoted at one of its ends, is hanging vertically. A bullet of the same mass moving at speed v strikes the rod horizontally at a distance x from its pivoted end and gets embedded in it. The combined system now rotates with angular speed ω about the pivot. The maximum angular speed ω_M is achieved for $x = x_M$. Then



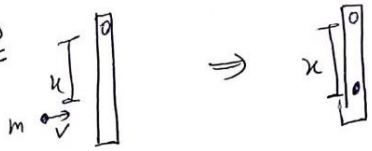
(A) $\omega = \frac{3vx}{L^2+3x^2}$

(B) $\omega = \frac{12vx}{L^2+12x^2}$

(C) $x_M = \frac{L}{\sqrt{3}}$

(D) $\omega_M = \frac{v}{2L}\sqrt{3}$

Q.9



Applying angular momentum conservation about suspension point

$$mvx = \left(\frac{ml^2}{3} + mx^2\right)w$$

$$\therefore w = \frac{mvx}{\frac{ml^2}{3} + mx^2} = \frac{2vx}{l^2+3x^2}$$

for w_{max}, differentiate above eqn

$$\frac{dw}{dx} = \frac{(l^2+3x^2)(2v) - 2vx(3)x2x}{(l^2+3x^2)^2} = 0 \quad \Rightarrow l^2+3x-3x\times 2x = 0$$

$$\Rightarrow \boxed{x_m = \frac{l}{\sqrt{3}} \quad \& \quad w_m = \frac{\sqrt{3}v}{2L}} \quad \text{Ans}$$

10

Q.10 In an X-ray tube, electrons emitted from a filament (cathode) carrying current I hit a target (anode) at a distance d from the cathode. The target is kept at a potential V higher than the cathode resulting in emission of continuous and characteristic X-rays. If the filament current I is decreased to $\frac{I}{2}$, the potential difference V is increased to $2V$, and the separation distance d is reduced to $\frac{d}{2}$, then

(A) the cut-off wavelength will reduce to half, and the wavelengths of the characteristic X-rays will remain the same

(B) the cut-off wavelength as well as the wavelengths of the characteristic X-rays will remain the same

(C) the cut-off wavelength will reduce to half, and the intensities of all the X-rays will decrease

(D) the cut-off wavelength will become two times larger, and the intensity of all the X-rays will decrease

Q.10

$\lambda_{min} = \frac{hc}{eV}$ $\quad \lambda_{min} \propto \frac{1}{V}$

So (λ_{min} will reduce to half.

$I = \frac{dN}{dt} \times \frac{hc}{\lambda}$ $\quad$ So as $I \downarrow \rightarrow \frac{dN}{dt}$ also decreased to half.

hence, intensity also decreases.

11

Q.11 Two identical non-conducting solid spheres of same mass and charge are suspended in air from a common point by two non-conducting, massless strings of same length. At equilibrium, the angle between the strings is α. The spheres are now immersed in a dielectric liquid of density 800 kg m^{-3} and dielectric constant 21. If the angle between the strings remains the same after the immersion, then

(A) electric force between the spheres remains unchanged

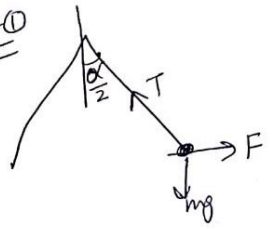
(B) electric force between the spheres reduces

(C) mass density of the spheres is 840 kg m^{-3}

(D) the tension in the strings holding the spheres remains unchanged

Q.11

Case-①

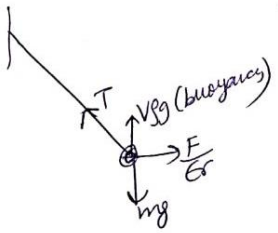


At eqm

$T\cos\frac{\alpha}{2} = mg$ — ①

$T\sin\frac{\alpha}{2} = F$ — ②

Case ② Immersed in dielectric liquid



$T'\cos\frac{\alpha}{2} + Vsg = mg$

$T'\cos\frac{\alpha}{2} = \frac{mg - Vsg}{}$ — ③

$T'\sin\frac{\alpha}{2} = \frac{F}{Gr}$ — ④

from ①, ②, ③, ④

$$\frac{F}{mg} = \frac{F/Gr}{mg - Vsg}$$

$Gr(mg - Vsg) = mg$ $\quad d$ = density of sphere

$Gr(d - s) = s$

$\Rightarrow \frac{1}{21} = 1 - \frac{s}{d} \Rightarrow$ $\boxed{d = 840}$

12

Q.12 Starting at time $t = 0$ from the origin with speed $1\ \text{ms}^{-1}$, a particle follows a two-dimensional trajectory in the x-y plane so that its coordinates are related by the equation $y = \frac{x^2}{2}$. The x and y components of its acceleration are denoted by a_x and a_y, respectively. Then

(A) $a_x = 1\ \text{ms}^{-2}$ implies that when the particle is at the origin, $a_y = 1\ \text{ms}^{-2}$

(B) $a_x = 0$ implies $a_y = 1\ \text{ms}^{-2}$ at all times

(C) at $t = 0$, the particle's velocity points in the x-direction

(D) $a_x = 0$ implies that at $t = 1$ s, the angle between the particle's velocity and the x axis is 45°

Q12 $y = \frac{x^2}{2}$

$\frac{dy}{dt} = x\frac{dx}{dt}$ $\quad v_y = x v_x$

$\frac{dv_y}{dt} = v_x\frac{dx}{dt} + x\frac{dv_x}{dt}$

$a_y = (v_x)^2 + x a_x$

A) If $a_x = 1$ & particle at origin (at $(0,0)$ $v_x = 1$ at $t = 0$)

$a_y = (v_x)^2$

$a_y = 1$

B) if $a_x = 0$

$a_y = (v_x)^2$ $\quad a_x = 0$, $\frac{dv_x}{dt} = 0$, v_x = constant

So $a_y = 1$ always

C) at $t = 0$ $\quad v_y = x v_x$ $\quad (x = 0, y = 0)$

So $v_y = 0$ & $v_x = 1$

Hence, particle towards +x dirn

D) $a_y = v_x^2 + x a_x$

$v_y = x v_x$

$a_x = 0$ (given)

$a_y = v_x^2$

If $a_x = 0$ $\quad a_y = 1$ constant.

at $t = 1$ sec $\quad v_y = v_y + at = 1$

$\tan\theta = \frac{v_y}{v_x} = x = 1$

hence $\theta = 45^0$

(All options are correct)

13

Q.13 A spherical bubble inside water has radius R. Take the pressure inside the bubble and the water pressure to be p_0. The bubble now gets compressed radially in an adiabatic manner so that its radius becomes $(R-a)$. For $a \ll R$ the magnitude of the work done in the process is given by $(4\pi p_0 R a^2)X$, where X is a constant and $\gamma = C_p/C_V = 41/30$. The value of X is_____.

Q13 work in adiabatic process $W = \dfrac{P_2V_2 - P_1V_1}{\gamma - 1}$

Also PV^γ = constant

So $P_1V_1^\gamma = P_2V_2^\gamma$

So $W = \dfrac{P_1\left(\frac{V_1}{V_2}\right)^\gamma \times V_2 - P_1V_1}{\gamma - 1} = \dfrac{30}{11}(P_1V_1)\left[\left(\frac{V_1}{V_2}\right)^{\gamma-1} - 1\right]$

$W = \dfrac{30}{11}P_1V_1\left[\left(\frac{R}{R-a}\right)^{3(\gamma-1)} - 1\right] = \dfrac{30}{11}P_1V_1\left[\dfrac{1}{\left(1-\frac{a}{R}\right)^{3(\gamma-1)}} - 1\right]$

using binomial

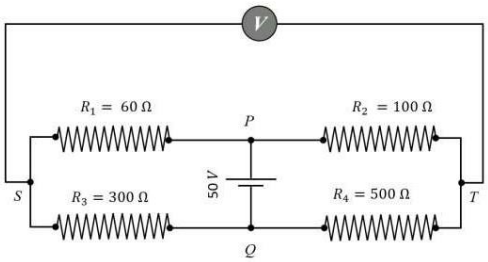
$W = \dfrac{30}{11}P_1V_1\left[\dfrac{a}{R} \times 3(\gamma-1)\right]$ $\left\{V_1 = \frac{4}{3}\pi R^3\right\}$

$W = (4\pi R^2 P_1 a) = 4\pi R^2 P_1 a$

$\Rightarrow \boxed{x = 1}$

14

Q.14 In the balanced condition, the values of the resistances of the four arms of a Wheatstone bridge are shown in the figure below. The resistance R_3 has temperature coefficient $0.0004\ °C^{-1}$. If the temperature of R_3 is increased by 100 °C, the voltage developed between S and T will be _____ volt.



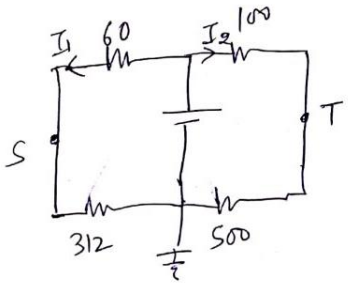
Q.14 On ↑ Temperature

$R_3' = 300(1+\alpha\Delta T)$

$= 300(1+0.0004\times100)$

$= 300(1.04)$

$= 312\ \Omega$



$I_1 = \frac{50}{60+312} \Rightarrow I_1 = \frac{50}{372}$

& $I_2 = \frac{50}{600} \Rightarrow I_2 = \frac{1}{12}$

$V_S - V_T = 312\,I_1 - 500\,I_2$

$= 41.94 - 41.66$

$= 0.27\ V$

15

Q.15 Two capacitors with capacitance values $C_1 = 2000 \pm 10$ pF and $C_2 = 3000 \pm 15$ pF are connected in series. The voltage applied across this combination is $V = 5.00 \pm 0.02$ V. The percentage error in the calculation of the energy stored in this combination of capacitors is _____.

Q.15

$$U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}V^2$$

$$\text{let } C_{eq} = \frac{C_1C_2}{C_1+C_2} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq} \pm \Delta C_{eq}} = \frac{1}{C_1 \pm \Delta C_1} + \frac{1}{C_2 \pm \Delta C_2}$$

$$\Rightarrow C_{eq} \pm \Delta C_{eq} \simeq \frac{C_1C_2 + C_1\Delta C_2 + C_2\Delta C_1}{C_1+C_2+\Delta C_1+\Delta C_2}$$

$$= \frac{1200\left(1 \pm \frac{12}{1200}\right)}{\left(1 \pm \frac{25}{5000}\right)} = 1200\left[1 \pm \left(\frac{1}{100} - \frac{1}{200}\right)\right]$$

$$U = \frac{1}{2}C_{eq}V^2$$

$$\log U = \log\frac{1}{2} + \log C_{eq} + 2\log V$$

$$\frac{\Delta U}{U} = 0 + \frac{\Delta C_{eq}}{C_{eq}} + 2\frac{\Delta V}{V}$$

$$\frac{\Delta U}{U} \times 100 = \frac{1}{200} \times 100 + 2 \times \frac{0.02}{5} \times 100$$

$$= 1.3\%$$

16

Q.16 A cubical solid aluminium (bulk modulus $= -V\frac{dP}{dV} = 70$ GPa) block has an edge length of 1 m on the surface of the earth. It is kept on the floor of a 5 km deep ocean. Taking the average density of water and the acceleration due to gravity to be 10^3 kg m^{-3} and 10 ms^{-2}, respectively, the change in the edge length of the block in mm is _____.

Q.16

$V = A^3$ for cube (A = side length)

$dV = 3A^2 dA$

$\frac{dV}{V} = \frac{3dA}{A}$

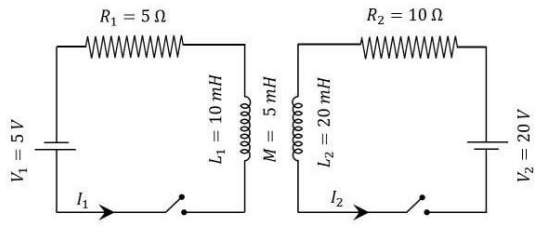
$B = -V\frac{dP}{dV} = \frac{-V(\rho g h)}{dV} = \frac{-\rho g h A}{3dA}$

$70 \times 10^9 = \frac{1 \times 5000 \times 10^3 \times 10 \times 1}{3\,dA}$

$\Rightarrow dA = \Delta A = \frac{5}{21} \times 10^{-2}\,m = 2.38\ mm.$

17

Q.17 The inductors of two *LR* circuits are placed next to each other, as shown in the figure. The values of the self-inductance of the inductors, resistances, mutual-inductance and applied voltages are specified in the given circuit. After both the switches are closed simultaneously, the total work done by the batteries against the induced *EMF* in the inductors by the time the currents reach their steady state values is_____ mJ.



Q.17 Mutual inductance in circuits is producing flux in same direction as self inductance

$\therefore U = \frac{1}{2}L_1 I_1^2 + \frac{1}{2}L_2 I_2^2 + M I_1 I_2$

$\Rightarrow U = \frac{1}{2}(10 \times 10^{-3}) I^2 + \frac{1}{2} \times (20 \times 10^{-3}) \times 2^2 + 5 \times 10^{-3} \times 1 \times 2$

$\boxed{U = 55\,mJ}$

18

Q.18 A container with 1 kg of water in it is kept in sunlight, which causes the water to get warmer than the surroundings. The average energy per unit time per unit area received due to the sunlight is 700 Wm^{-2} and it is absorbed by the water over an effective area of 0.05 m^2. Assuming that the heat loss from the water to the surroundings is governed by Newton's law of cooling, the difference (in °C) in the temperature of water and the surroundings after a long time will be _____. (Ignore effect of the container, and take constant for Newton's law of cooling = 0.001 s^{-1}, Heat capacity of water = 4200 $J\,kg^{-1}\,K^{-1}$)

Q18 At eqlm

Heat received per sec = Heat lost per sec.

$EXA = kmS\Delta T \times M$

$\Rightarrow \Delta T = \frac{EA}{KSM} = \frac{700 \times 0.05}{10^{-3} \times 4200 \times 1}$

$\boxed{\Delta T = 8.33\,^{\circ}C}$

Energy per unit time per unit area = 700 W/m^2

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