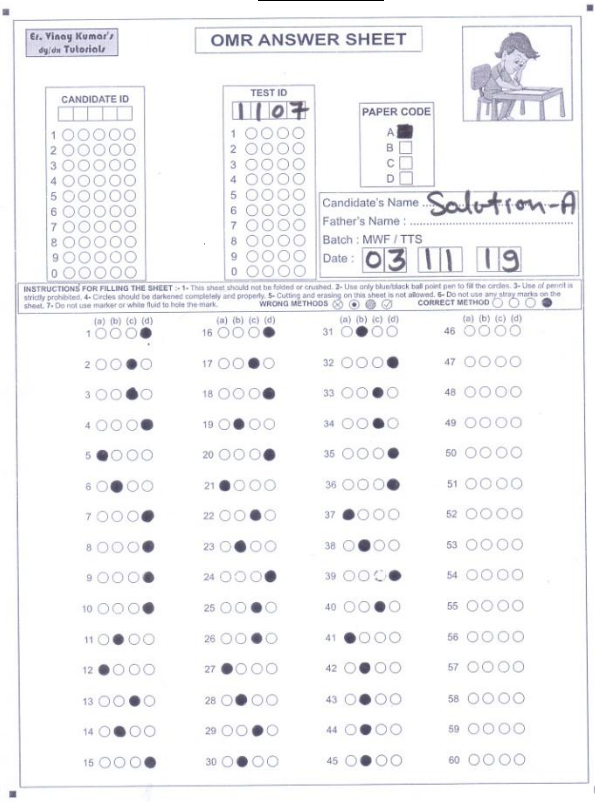
SET-A



Q1. $S=\frac{1}{2}g\cdot 2^2$ .... (1)

$S_T=\frac{1}{2}g\,(2T-1)$ .... (2)

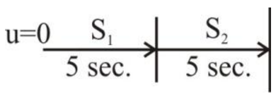
$S=S_T \Rightarrow =\frac{1}{2}g\cdot 2^2=\frac{1}{2}g\,(2T-1)$

$\Rightarrow 4=2T-1 \Rightarrow T=5/2\,\text{sec}.$

$H=\frac{1}{2}gT^2=\frac{1}{2}\times 10\times\left(\frac{5}{2}\right)^2$

$H=\frac{1}{2}\times 10\times\frac{25}{4} \Rightarrow H=31.25\text{m}$

Q2.



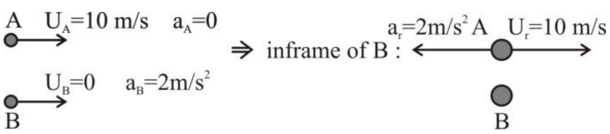
$S_1=\frac{1}{2}a\,5^2$ ....(1)

$S_1+S_2=\frac{1}{2}a\,(5+5)^2 \Rightarrow S_1+S_2=\frac{1}{2}a\,10^2$ ....(2)

$\frac{(2)}{(1)} \Rightarrow \frac{S_1+S_2}{S_1}=\left(\frac{10}{5}\right)^2 \Rightarrow \frac{S_1+S_2}{S_1}=4$

$\Rightarrow S_1+S_2=4S_1 \Rightarrow S_2=3S_1$

Q3.



If the bodies meet again then Sr should be zero.

$S_r=U_r t+\frac{1}{2}a_r t^2 \Rightarrow 0=10\times t+\frac{1}{2}\times(-2)\times t^2$

$\Rightarrow 0=10t-t^2 \Rightarrow t^2=10t \Rightarrow t=10\,\text{sec}.$

Q4. $S=\frac{t^3}{3}-2t^2+3t$

$\Rightarrow \frac{ds}{dt}=\frac{3t^2}{3}-2\times 2t+3=0 \Rightarrow t^2-4t+3=0$

$\Rightarrow t^2-3t-t+3=0 \Rightarrow t\,(t-3)-(t-3)=0$

$\Rightarrow (t-1)\,(t-3)=0 \Rightarrow t=1\text{ and }3\,\text{sec}.$

Q7. $W=\Delta kE \Rightarrow -mgh=\frac{1}{2}\left(\frac{1}{2}m4^2\right)-\frac{1}{2}m4^2$

$\Rightarrow -mgh=-\frac{1}{4}m4^2 \Rightarrow gh=4 \Rightarrow h=0.4\text{m}$

Q8. $x=t^3+2t^2+2 \Rightarrow \frac{dx}{dt}=3t^2+4t$

$\Rightarrow V=3t^2+4t \Rightarrow V_{t=0}=0$ &

$V_{t=1}=3\times 1^2+4\times 1=7\text{m/s}$

$W=\Delta KE=KE_f-KE_i$

$\Rightarrow W=\frac{1}{2}\times 4\times 7^2-\frac{1}{2}\times 4\times 0^2=98\text{J}$

Q9. -ve graph shows work done on the system and increase in pot. energy of the system.

Since pot. energy is increasing the system is becoming unstable

Q11. $U=\frac{1}{2}\frac{\sigma^2}{E}\cdot V=\frac{1}{2}\frac{F^2}{A^2}\cdot Al=\frac{1}{2}\frac{F^2}{AE}\times l$

E & F are same in the given case $\Rightarrow U\propto\frac{l}{A}$

$\Rightarrow \frac{U_A}{U_B}=\frac{l_A}{l_B}\frac{A_B}{A_A}=\frac{l_A}{l_B}\times\left(\frac{d_B}{d_A}\right)^2=\frac{3}{1}\times\left(\frac{1}{2}\right)^2$

$=\frac{3}{4}$

Q12. $P=-\frac{\Delta D/D}{\Delta l/l}$

$\Rightarrow 0.20=-\frac{\Delta D/D}{2\times 10^{-3}} \Rightarrow \frac{\Delta D}{D}=-4\times 10^{-4}$ ……(1)

Volume of rod $V=\frac{\pi D^2}{4}\times l \Rightarrow V\propto D^2\times l$

$$\Rightarrow \frac{\Delta V}{V} = 2\frac{\Delta D}{D} + \frac{\Delta l}{l}$$

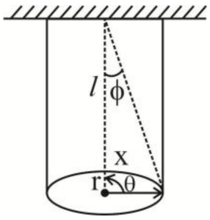
$$\Rightarrow \frac{\Delta V}{V} = 2[-4\times10^{-4}] + 2\times10^{-3}$$

$$\Rightarrow \frac{\Delta V}{V} = -8\times10^{-4} + 20\times10^{-4}$$

$$\Rightarrow \frac{\Delta V}{V} = 12\times10^{-4}$$

$$\% \frac{\Delta V}{V} = 12\times10^{-4}\times100 = 12\times10^{-2} = +0.12$$

Q13. $x = \theta\cdot r = \phi\cdot l$



$30^o \times 4\text{mm} = \phi\times1000\text{ mm}$

$\phi = 0.12^o$

Q14. Force required $= \sigma_t A = \alpha Y \Delta t\cdot A$

$= 10^{-5}\times10^{11}\times(100-0)\times1\times10^{-4} = 10^4 N$

Q15. at maximum speed the kinetic energy becomes maximum or potential energy becomes minimum.

$KE_{maximum} = E_{total} - U_{minimum}$ ..... (1)

for $U_{minimum}$.

$$\frac{dU}{dx} = u \Rightarrow \frac{d}{dx}[20+(x-2)^2] = 0$$

$$\Rightarrow 2(x-2) = 0 \Rightarrow x = 2$$

$$u_{min} = 20 + (2-2)^2 = 20J \quad ...... (2)$$

at x=2

$E=U+KE=U_{x=5} + KE_{x=5} = 20 + (5-2)^2 + 20$

= 20 + 9 + 20 = 49 J .... (3)

from eq. (1), (2) & (3) $KE_{max} = 49 - 20 = 29$ J

$$\frac{1}{2}mv_{max}^2 = 29 \Rightarrow \frac{1}{2}\times1\times v^2 = 29$$

$$\Rightarrow v_{max}^2 = 2\times29$$

$$\Rightarrow v_{max}^2 = 58 \Rightarrow v_{max} = \sqrt{58}\ m/s$$

Q16. $W = \Delta U$

$$\Rightarrow W = U_f - U_i = \frac{1}{2}k\left[(0.3+0.15)^2 - 0.3^2\right]$$

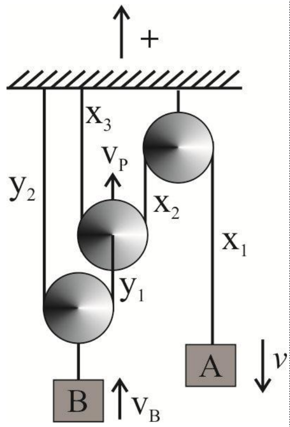
$$= \frac{1}{2}k[0.45^2 - 0.3^2] \Rightarrow W = \frac{1}{2}k\times0.1125 \quad ...(1)$$

$$\frac{1}{2}k(0.3)^2 = 10J \Rightarrow \frac{1}{2}k = \frac{30}{(0.3)^2} \quad .... (2)$$

from eq. (1) & (2)

$$W = \frac{10}{(0.3)^2}\times0.1125 = 12.5J$$

Q17. $x_1 + x_2 + x_3 = l$



$v - v_P - v_P = 0$

$$\Rightarrow v_P = v/2 \quad .... (1)$$

$$y_1 + y_2 = l'$$

$$\Rightarrow (v_P - v_B) - v_B = 0$$

$$\Rightarrow v_P = 2v_B \quad ...... (2)$$

from (1) & (2) :

$$\frac{v}{2} = 2v_B \Rightarrow v_B = \frac{v}{4}$$

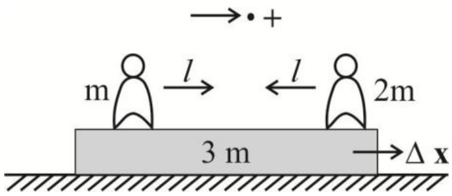
$$Mv_0 = m_1v_1 + m_2v_2$$

$$\Rightarrow (m+m)v_0 = m(-v) + m\left(+\frac{v}{4}\right)$$

$$\Rightarrow 2mv_0 = -mv + \frac{mv}{4}$$

$$\Rightarrow 2v_0 = -\frac{3v}{4} \Rightarrow v_0 = -\frac{3v}{8}$$

Q18.



$$M\Delta x_0 = m_1\Delta x_1 + m_2\Delta x_2 + m_3\Delta x_3$$

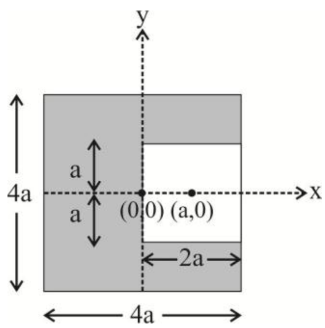
$$(m+2m+3m)\times0 = m[+(l+\Delta x)]$$

$$+2m[+(\Delta x - l)] + 3m(+\Delta x)$$

$$\Rightarrow 0 = ml + m\Delta x + 2m\Delta x - 2ml + 3m\Delta x$$

$$\Rightarrow 6m\Delta x = ml \Rightarrow \Delta x = l/6$$

Q19. $m_1 = \sigma(4a)^2 = 16a^2\sigma$



$x_1 = 0$

$$m_2 = \sigma(2a)^2 = 4a^2\sigma$$

$x_2 = a$

$$x_0 = \frac{m_1x_1 - m_2x_2}{m_1 - m_2}$$

$$= \frac{16a^2\sigma \times 0 - 4a^2\sigma \times a}{16a^2\sigma - 4a^2\sigma}$$

$$= -\frac{4a}{12} = -\frac{a}{3}$$

$y_0 = 0$

Q20. $Y_A = \tan 60^o = \sqrt{3}$

$$Y_B = \tan 30^o = \frac{1}{\sqrt{3}}$$

$$\frac{Y_A}{Y_B} = \frac{\sqrt{3}}{1/\sqrt{3}} = 3 \Rightarrow Y_A = 3Y_B$$

Q21. $W = \Delta kE \Rightarrow Wmg + W_{fr} + W_s = kE_f - kE_i$

$$\Rightarrow mg\, x \sin 37^o - \mu k\, mg\, x \cos 37^o$$

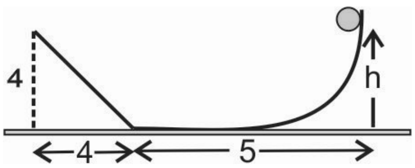
$$-\frac{1}{2}kx^2 = \frac{1}{2} \times 2 \times v^2 - 0$$

$$\Rightarrow 2 \times 10 \times 0.5 \times \frac{3}{5} - \frac{1}{8}$$

$$\times 2 \times 10 \times 0.5 \times \frac{4}{5} - \frac{1}{2} \times 8 \times (0.5)^2 = v^2$$

$$\Rightarrow 6 - 1 - 1 = v^2 \quad \Rightarrow \quad v = 2m/s$$

Q22.



$$W = \Delta kE \quad \Rightarrow \quad W_{mg} + W_{fr} + W_R = kE_t - kE_i$$

$$\Rightarrow (mg \times 4 - mgh) - 0.4mg(4+5) + 0 = 0 - 0$$

$$\Rightarrow 4 - h - 3.6 = 0 \quad \Rightarrow \quad h = 0.4m$$

Q23. $W = \Delta kE \quad \Rightarrow \quad W_{mg} + W_T + W_R = kE_f - kE_i$

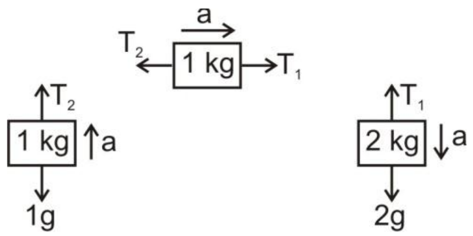
$$\Rightarrow mg\left(h + \frac{h}{2}\right) - \frac{1}{2}k\left(\frac{h}{2}\right)^2 + 0 = 0 - 0$$

$$\Rightarrow mg \cdot \frac{3h}{2} = \frac{1}{2}k\frac{h^2}{4} \quad \Rightarrow \quad h = \frac{12mg}{k}$$

Q24. 2a = 2g – T_1 ………. (1)

1a = T_1 – T_2 ……… (2)

1a = T_2 – 1g ……… (3)



(1) + (2) + (3) : $4a = g \quad \Rightarrow \quad a = g/4 = \frac{5}{2}$

$$m\,\vec{a}_0 = m_1\vec{a}_1 + m_2\vec{a}_2 + m_3\vec{a}_3$$

$$4\,\vec{a}_0 = -2aj + 1 \cdot ai + 1 \cdot aj$$

$$\Rightarrow 4\,\vec{a}_0 = ai - aj \quad \Rightarrow \quad \vec{a}_0 = \frac{a}{4}(i - j)$$

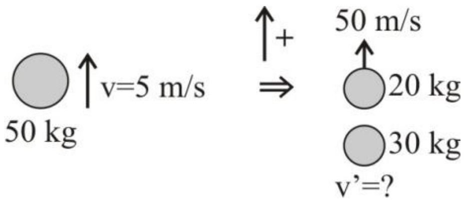
$$a_o = \frac{a}{4}\sqrt{2} = \frac{5}{2 \times 4} \times \sqrt{2} = \frac{5\sqrt{2}}{8} m/s^2$$

Q27. After 5 sec, velocity of body :

$v = u + at$

$$\Rightarrow v = 100 - g \times 5 = 100 - 9.8 \times 5 = 100 - 49$$

= 51 m/s



<u>P</u>

$P_i = P_f$ $50 \times 51 = 150 \times 20 + 30v'$

$$\Rightarrow 2550 = 3000 + 30v'$$

$$\Rightarrow 30v' = -450 \quad \Rightarrow \quad v' = -15 \; m/s$$

Q29. $\frac{KE_f}{KE_i} = \frac{3}{4}$

$$\Rightarrow \frac{\Delta KE}{KE_i} = \frac{KE_i - KE_f}{KE_i} = 1 - \frac{KE_f}{KE_i} = 1 - \frac{3}{4} = \frac{1}{4}$$

$$\Rightarrow \frac{\Delta KE}{KE_i} = \frac{1}{4} \quad \Rightarrow \quad \frac{\frac{1}{2}\mu u_r^2(1-e^2)}{\frac{1}{2}mv^2} = \frac{1}{4}$$

$$\Rightarrow \frac{\frac{1}{2} \times \left(\frac{m \times m}{m+m}\right)\,(v-0)^2(1-e^2)}{\frac{1}{2}mv^2} = \frac{1}{4}$$

$$\Rightarrow \frac{\frac{1}{2}\times\frac{m}{2}\times v^2(1-e^2)}{\frac{1}{2}mv^2}=\frac{1}{4}$$

$$\Rightarrow \frac{(1-e^2)}{2}=\frac{1}{4} \Rightarrow 1-e^2=\frac{1}{2} \Rightarrow e^2=\frac{1}{2}$$

$$e=\frac{1}{\sqrt{2}}$$

Q30. $h_n = 2^{en}h$

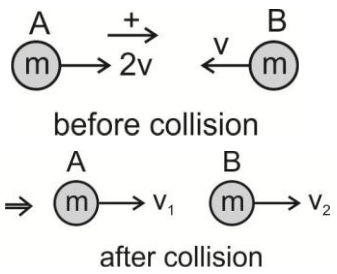
$$\Rightarrow h_2 = e^{2\times 2}h = \left(\frac{1}{2}\right)^4 \times 32 = \frac{1}{16}\times 32 = 2m$$

Q31. $\Delta KE = \frac{1}{2}\mu U_r^2\,(1-e^2)$

$$=\frac{1}{2}\times\left(\frac{M\times M}{M+M}\right)(U+2U)^2(1-0)$$

$$=\frac{1}{2}\times\frac{M^2}{2M}\times 9U^2=\frac{9}{4}MU^2$$

Q32.



pi = pt $\Rightarrow \quad m\times 2v + m(-v) = mv_1 + mv_2$

$\Rightarrow \quad v_1 + v_2 = v$ …….. (1)

N-Exp. Law $\Rightarrow \quad \frac{v_2 - v_1}{(-v)-(2v)} = -\frac{1}{2}$

$\Rightarrow \quad v_2 - v_1 = \frac{3v}{2}$ …….. (2)

$(1)-(2):\ 2v_1 = -\frac{v}{2} \quad \Rightarrow \quad v_1 = -v/4$

Q33. $\Delta S = \mu C_p\, ln\frac{T_f}{T_i} - \mu R\, ln\frac{P_f}{P_i}$

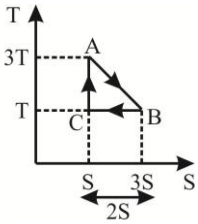
For isobaric process : Pf = Pi

$\Rightarrow \Delta S = \mu C_P\ ln\frac{T_f}{T_i} - 0 = \mu C_P\ ln\frac{T_f}{T_i}$ …….. (1)

Since $V \alpha T$ in isobaric process $\Rightarrow \frac{T_f}{T_i}=\frac{V_f}{V_i}$

From eq. (1) $\Delta S = \mu\, C_P\ ln\frac{V_f}{V_i}$

Q34. $Q_{AB} = \frac{1}{2}(3T+T)2S = 4TS$



$Q_{BC} = -T\times 2S = -2TS$

$Q_{CA} = 0$

$Q_h = 6TS,\ Q_l = 2TS$

$\Rightarrow \eta = 1-\frac{Q_l}{Q_h} = 1-\frac{2TS}{4TS} = 1-\frac{1}{2} = \frac{1}{2}$

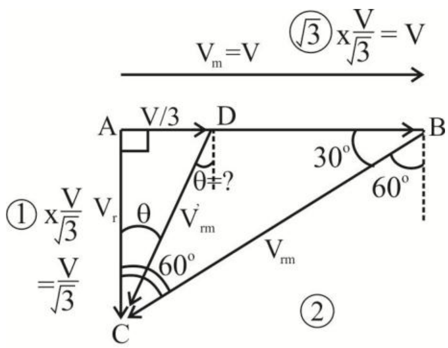
Q37. $\Delta S = \mu\, Cv\, ln\frac{P_t}{P_i}$

$$=1\times\frac{R}{\frac{7}{5}-1}\times ln\frac{2P}{P}$$

$$=\frac{5R}{2}ln2 = 2.5R\ ln2$$

Q40. Due to intermolecular force the gas has to do work during its expansion against this intermolecular force. This work is done from the internal energy, hence its internal energy decreases and therefore temperature decreases.

Q41.



In Δ ACD

$$\tan\theta = \frac{V/3}{V/\sqrt{3}} = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}}$$

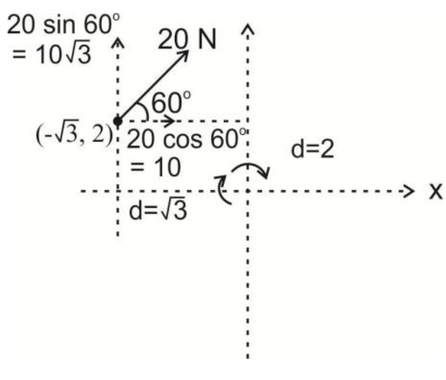
$\theta = 30^\circ$

Q42. $\tau = \tau_x + \tau_y$

$$=(+10\times 2)+(+10\sqrt{3}\times\sqrt{3})$$

= 20 + 30

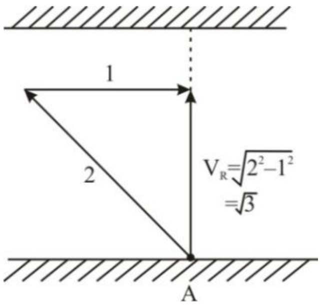
= + 50 Nm



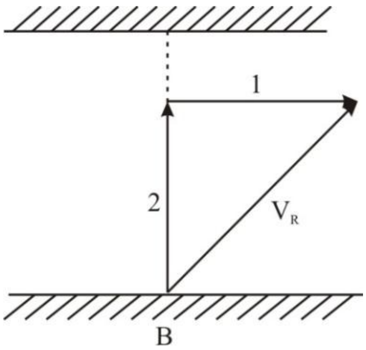
Q43. For vectors to be coplanar $\left(\vec{A}\times\vec{B}\right)\cdot\vec{B}=0$

$$\vec{A}=2i-3j+k$$
$$\vec{C}=\ i+j+4k$$
$$\vec{A}\times\vec{C}=-13i-7j+5k$$
$$\left(\vec{A}\times\vec{C}\right)\cdot\vec{B}=0$$
$$(-13i-7j+5k)\cdot(i+j+2\,mk)$$
$$-13-7+10m=0\ \Rightarrow\ 10\,m=20$$
$$\Rightarrow\ m=2$$

Q44.



$$t_A=\frac{d}{V_R}=\frac{2\sqrt{3}}{\sqrt{3}}=2\text{hr}$$



$$t_B=\frac{d}{V}=\frac{2\sqrt{3}}{2}=\sqrt{3}$$

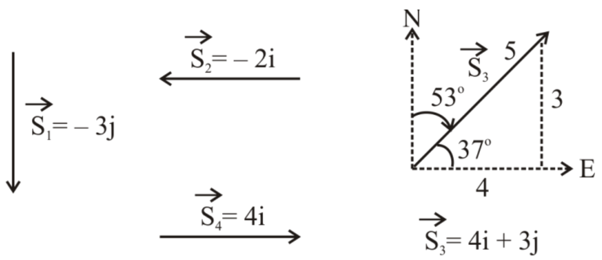
= 1.73 hr

$\Delta t=t_A=t_B$

= 2 – 1.73

= 0.27 hr

Q45.



$$\vec{S}=\vec{S}_1+\vec{S}_2+\vec{S}_3+\vec{S}_4$$

$$=-3j-2i+4i+3j+4i=6i\ \Rightarrow\ \text{6m, east}$$