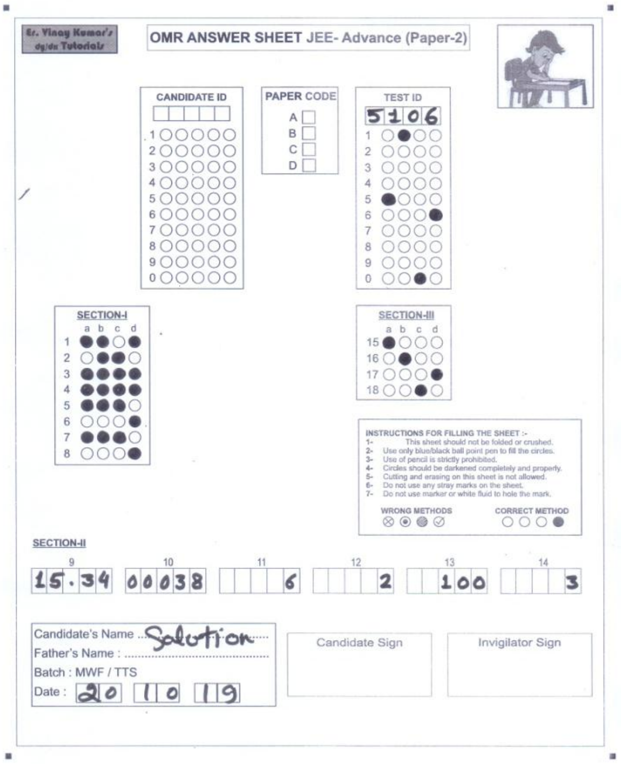
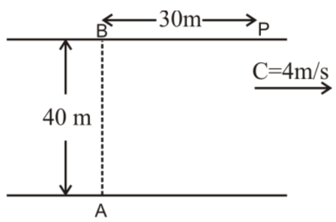


Q2.



$$x = (v\sin\theta + c)\frac{d}{v\cos\theta}$$

$$30 = (v\sin\theta + 4)\frac{40}{v\cos\theta}$$

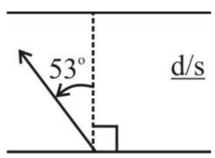
$$\frac{3v}{4}\cos\theta = v\sin\theta + 4$$

$$v\left[\frac{3}{4}\cos\theta - \sin\theta\right] = 4 \;\ldots\ldots\ldots\ldots\; (1)$$

$$\cdot\left[\frac{3}{4}\cos\theta - \sin\theta\right] + v\left[\frac{3}{4}(-\sin\theta) - \cos\theta\right] = 0$$

$$\frac{3}{4}(-\sin\theta) = \cos\theta$$

$$\Rightarrow \quad \tan\theta = -\frac{4}{3}$$



$\Rightarrow \quad \theta = -53^{o}$ (–ve sign means on left side of vertical line)

Direction from d/s $\to 90^{o} + 53^{o} =$ **143°**

From eq. (1)

$$v_{min}\left[\frac{3}{4}\cos(-53^{o}) - \sin(-53^{o})\right] = 4$$

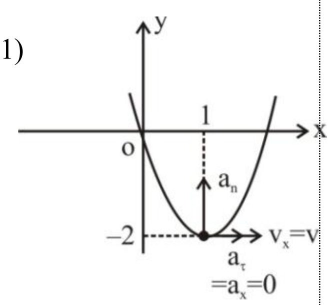
$$v_{min}\left[\frac{3}{4}\times\left(\frac{3}{5}\right) + \frac{4}{5}\right] = 4 \Rightarrow \quad v_{min}\left[\frac{9}{20} + \frac{4}{5}\right] = 4$$

$$\Rightarrow \quad v_{min}\left[\frac{5}{4}\right] = 4 \quad \Rightarrow \quad v_{min} = \frac{16}{5} m/s$$

Q3. $y = 2x^2 - 4x$

$$\frac{dy}{dt} = 4x\frac{dx}{dt} - 4\frac{dx}{dt} \Rightarrow v_y = 4xv_x - 4v_x$$

$$\Rightarrow v_y = 4v_x(x-1) \;\ldots.\; (1)$$



at vertex

$x = 1$

$y = -2$

$\Rightarrow \quad v_x = v$, $v_y = 0$

(as velocity can be tangential only)

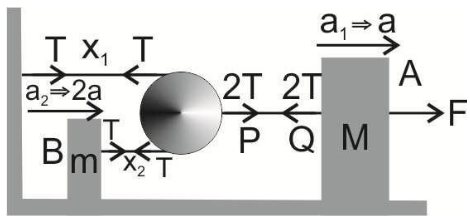
$a_\tau = a_x = 0$ (as $v_x = v$ is constant)

$$\Rightarrow \frac{dv_y}{dt} = 4\left[v_x\left(\frac{dx}{dt}\right) + (x-1)a_x\right]$$

$$\Rightarrow a_y = 4\left[v_x^2 + (x-1)\,a_x\right] \;\ldots\ldots\ldots\ldots\; (2)$$

at $x = 1,\; a_y = 4v_x^2 \;\; = 4v^2$

Q4. $x_1 + x_2 = l$



$a_1 + (a_1 - a_2) = 0$

$2a_1 = a_2 \Rightarrow$ if $a_1 = a$

then $a_2 = 2a$

$Ma = F - 2T$ ....(1)

$m_2a = T$ .... (2)

$(1) + (2)\times 2 :\; Ma + 3ma = F \;\Rightarrow\; a = F/(M+4m)$

$a_2 = 2a = 2F/(M+4m)$

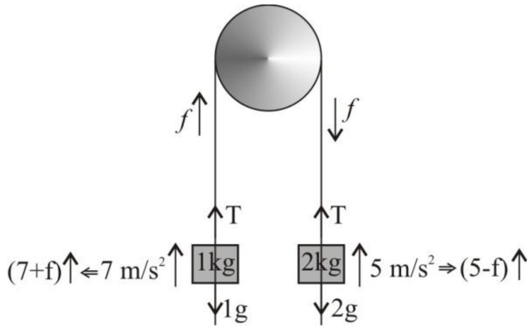
from eq. (2) $m\times\dfrac{2F}{(M+4m)} = T$

$\Rightarrow T = 2mF/(M+4m)$

Tension in connector $\Rightarrow 2T = 4mF/(M+4m)$

Q5. $2(5 - f) = T - 2g$ .... (1)

$1(7 + f) = T - 1g$ .... (2)



$(1)-(2): 3-3f=-g \;\Rightarrow\; 3-3f=-10$

$\Rightarrow\; 3f=13 \;\Rightarrow\; f=\dfrac{13}{3} \;\Rightarrow\; f=4.3\,m/s^2$

acc. of 1 kg body :

$\Rightarrow\; 7+f=7+4.3=11.3\,m/s^2$

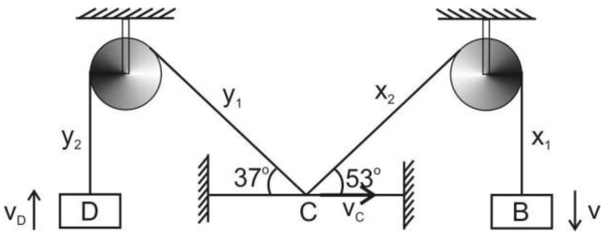
acc. of 2 kg body :

$\Rightarrow\; 5-f=5-4.3=0.7\,m/s^2$

from eq. (1) : $2(5-4.3)=T-2\times10$

$\Rightarrow\; 1.4=T-20 \;\Rightarrow\; T=21.4\,N$

Q6.



$x_1+x_2=l$

$\Rightarrow\; v-v_C\cos53^o=0$

$\Rightarrow\; v-v_C\dfrac{3}{5}=0$

$\Rightarrow\; v_C=\dfrac{5}{3}v$ …….. (1)

$y_1+y_2=l_2$

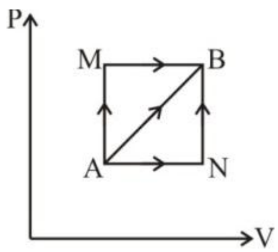
$\Rightarrow\; v_C\cos37^o-v_D=0$

$\Rightarrow\; v_C\dfrac{4}{5}=v_D \;\Rightarrow\; v_C=\dfrac{5}{4}v_D$ …….. (2)

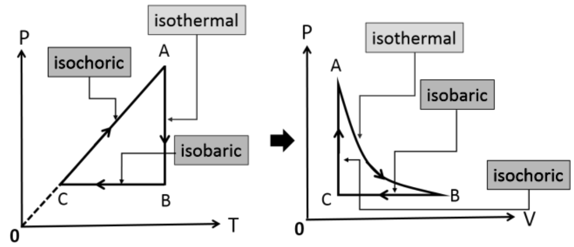
Equating (1) & (2) $\Rightarrow \dfrac{5}{3}v=\dfrac{5}{4}v_D$

$\Rightarrow\; v_D=\dfrac{4}{3}v$

Q7. In all the processes ΔU is same as initial & final states are same as $Q=\Delta U+W$ therefore Q depends only on W. $W_{AMB} > W_{AB} > W_{ANB}$ as area of AMB process is greater than process AB which is greater than process ANB, hence $Q_1 > Q_2 > Q_3$



Q8.



Q9.

T	Error=$T \sim T_{mean}$	Error = ΔT
0.52	0.52~0.58	0.06
0.58	0.56~0.58	0.02
0.62	0.57~0.58	0.01
0.58	0.54~0.58	0.04
0.60	0.59~0.58	0.01

$$T_{mean}=\frac{0.52+0.58+0.62+0.58+0.60}{5}=\frac{2.90}{5}$$

$=0.58$

Error = ΔT
0.06
0.02
0.01
0.04
0.01

$$\Delta T_{mean}=\frac{0.06+0.02+0.01+0.04+0.01}{5}$$

$$=\frac{0.14}{5}=0.028\approx0.03$$

$$\%\,Error\ in\ T=\frac{\Delta T_{mean}}{T_{mean}}\times100$$

$$=\frac{0.03}{0.58}\times100=5.17\%$$

For % error in measurement of g ⇨

$$T=2\pi\sqrt{\frac{3(l-r)}{5g}} ⇨ T\propto\sqrt{\frac{(l-r)}{g}} \quad ⇨ T^2\propto\frac{(l-r)}{g}$$

$$⇨ g\propto\frac{(l-r)}{T^2} \quad ⇨ \frac{\Delta g}{g}=\frac{\Delta(l-r)}{(l-r)}-2\frac{\Delta T}{T}$$

$$⇨ \frac{\Delta g}{g}=\frac{(\Delta l-\Delta r)}{(l-r)}-2\frac{\Delta T}{T}$$

$$maximum\ error ⇨ \frac{\Delta g}{g}=\frac{(\Delta l+\Delta r)}{(l-r)}+2\frac{\Delta T}{T}$$

$$⇨ \frac{\Delta g}{g}=\frac{(1+1)}{(50-10)}+2\times\frac{5.17}{100} \quad ⇨ \frac{\Delta g}{g}=\frac{2}{40}+\frac{10.34}{100}$$

$$⇨ \%\frac{\Delta g}{g}=\frac{2}{40}\times100+\frac{10.34}{100}\times100$$

$$⇨ \%\frac{\Delta g}{g}=5\%+10.34\% ⇨ \%\frac{\boldsymbol{\Delta g}}{\boldsymbol{g}}=\mathbf{15.34}\%$$

Q10.

$$P=\frac{100}{f\ in\ cm} ⇨ P_o=\frac{100}{f_o} ⇨ 100=\frac{100}{f_o} ⇨ f_o=1cm$$

$$P_e=\frac{100}{f_e} ⇨ 20=\frac{100}{f_e} \quad ⇨ f_e=5cm$$

$\Rightarrow M_i = m_o M_e \quad \Rightarrow M_i = \left(\frac{f_o - v_{oi}}{f_o}\right)\left(1 + \frac{D}{f_e}\right)$

$\Rightarrow -50 = \left(\frac{1 - v_{oi}}{1}\right)\left(1 + \frac{25}{5}\right) \Rightarrow -50 = \left(\frac{1 - v_{oi}}{1}\right)\left(\frac{30}{5}\right)$

$\Rightarrow -50 = (1 - v_{oi}) \times 6 \quad \Rightarrow -50 = 6 - 6v_{oi}$

$\Rightarrow 6v_{oi} = 56 \quad \Rightarrow v_{oi} = \frac{56}{6} \Rightarrow v_{oi} = \frac{28}{3}$

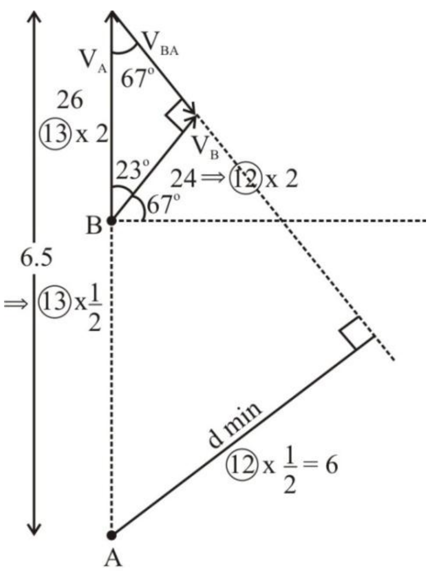
$\Delta L = v_{of} - v_{oi} \quad \Rightarrow -2 = v_{of} - \frac{28}{3} \Rightarrow v_{of} = \frac{28}{3} - 2$

$\Rightarrow v_{of} = \frac{28 - 6}{3} \Rightarrow v_{of} = \frac{22}{3}$

$M_f = \left(\frac{f_o - v_{of}}{f_o}\right)\left(1 + \frac{D}{f_e}\right) \Rightarrow M_f = \left(\frac{1 - \frac{22}{3}}{1}\right)\left(1 + \frac{25}{5}\right)$

$\Rightarrow M_f = -\frac{19}{3} \times \frac{30}{5} \quad \Rightarrow M_f = -\frac{19}{3} \times 6 \quad \Rightarrow \boldsymbol{M_f = -38}$

Q11.



in frame of A

Q12. $\vec{a} = \frac{d\vec{v}}{dt} = \frac{dx}{dt} i = v_x i = x\, i \Rightarrow a = x$

$a_\tau = \frac{dv}{dt} = \frac{d}{dt}\sqrt{x^2 + 1} = \frac{1}{2} \times \frac{1}{\sqrt{x^2+1}} \cdot 2x\frac{dx}{dt}$

$= \frac{xv_x}{\sqrt{x^2+1}} = \frac{x^2}{\sqrt{x^2+1}}$

$a_n = \sqrt{a^2 - a_\tau^2} = \sqrt{x^2 - \left(\frac{x^2}{\sqrt{x^2+1}}\right)^2} = \sqrt{x^2 - \frac{x^4}{(1+x^2)}}$

$= \sqrt{\frac{1 + x^4 - x^4}{1 + x^2}} = \frac{1}{\sqrt{1+x^2}}$

$r = \frac{v^2}{a_n} = \frac{x^2 + 1}{\frac{1}{\sqrt{1+x^2}}} = (1 + x^2)^{3/2}$

<u>at x=1</u> $r = (1 + 1^2)^{3/2} = 2\sqrt{2}$

$2\sqrt{\alpha} = 2\sqrt{2} \Rightarrow \alpha = 2$

Q13. $VT^2 = const.$

$[PV \propto T]$

$\Rightarrow VP^2V^2 = const \Rightarrow P^2 V^3 = const$

$\Rightarrow PV^{3/2} = const \Rightarrow n = 3/2$

$C = C_V + \frac{R}{1-n}$

$\Rightarrow C = \frac{R}{\gamma - 1} + \frac{R}{1-n} = \frac{R}{\frac{7}{5} - 1} + \frac{R}{1 - \frac{3}{2}}$

$= \frac{R}{\frac{2}{5}} - \frac{R}{\frac{1}{2}} = \frac{5}{2}R - 2R = \frac{R}{2}$

$Q = \mu C \Delta T$

$= 2 \times \frac{R}{2} \times (200 - 100) = R \times 100$

$= +\mathbf{100}\, \boldsymbol{R}$ [+ ve⇨ Heat given to the gas]

Q14.

Let the condition be limiting:

$f_{r_{max}} = \mu_s R$

$= 0.5 \times 10g = 50N$

$10a_1 = 70 - 50$

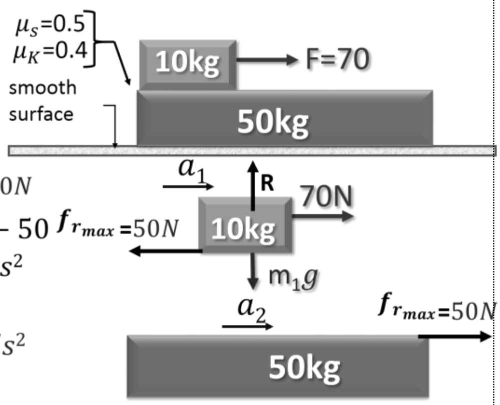
⇨ $a_1 = 2 m/s^2$

$50a_2 = 50$

⇨ $a_2 = 1 m/s^2$

$a_1 > a_2$

⇨ Condition is kinetic



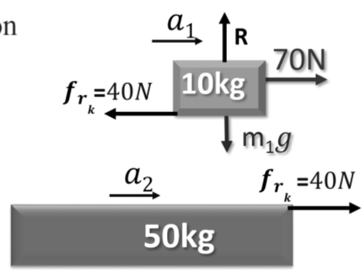
⇨ for kinetic condition

$f_r = \mu_k R$

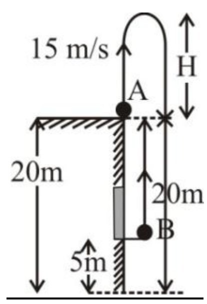
$= 0.4 \times 10g = 40N$

$10a_1 = 70 - 40$

$\Rightarrow \boldsymbol{a_1 = 3\ m/s^2}$



Q15.



(p) $s = ut + \frac{1}{2}at^2 \Rightarrow -20 = 15t + \frac{1}{2}(-10)t^2$

$\Rightarrow -20 = 15t - 5t^2 \Rightarrow 5t^2 - 15t - 20 = 0$

$\Rightarrow\ t^2-3t-4=0\ \Rightarrow\ t^2-4t+t-4=0$

$\Rightarrow\ (t-4)(t+1)=0\ \Rightarrow\ t=4\text{sec.}$

(q) in frame of B

$u_r\ \Rightarrow\ u_{AB}=20-15=5\text{ms}\downarrow a_r=g-g=0$

$s_r=u_rt+\frac{1}{2}a_rt^2\ \Rightarrow\ 15=5\times t\ \Rightarrow\ t=3\text{sec.}$

(r) the position of A after 3 sec.

$s=ut+\frac{1}{2}at^2\ \Rightarrow\ s=15\times3+\frac{1}{2}(-10)\times3^2$

$\Rightarrow\ s=45-45=0$ i.e. at the top of building from where the body A is thrown (i.e. 20 m above the ground)

(s) distance traveled = 2H and

$u^2=2gh\ \Rightarrow\ 15^2=2\times10\times H$

$\Rightarrow\ H=\frac{15\times15}{20}\ \Rightarrow\ H=\frac{225}{20}=11.25$

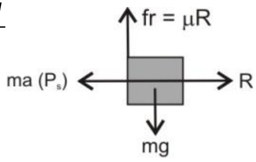
distance travelled

= H + H + 20

= 11.25+11.25+20=42.5

Q16. **(a) for the system :**

$2ma=F\ \Rightarrow\ a=\frac{F}{2m}=\frac{4mg}{2m}$



$\Rightarrow\ a=2g$ ……….. (1)

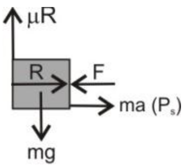
for body A : $R=ma=m2g$ ………. (2)

$fr=\mu R=mg\ \Rightarrow\ \mu\,2mg=mg\ \Rightarrow\ \mu=\frac{1}{2}$

(b) for the system :

$2ma=F\ \Rightarrow\ 2ma=4mg$

$\Rightarrow\ a=2g$ …. (1)



for the body A

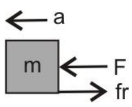
$R+ma=F\ \Rightarrow\ R+m.2mg=4mg$

$\Rightarrow\ R=2mg$

$fr=\mu R=mg\ \Rightarrow\ \mu\,2mg=ma$

$\Rightarrow\ \mu=\frac{1}{2}$

(c) for the system : $2ma=F$



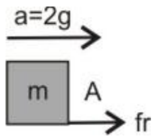
$\Rightarrow\ a=F/2m=\frac{4ma}{2m}=2g$ ………. (1)

for body A : $ma=F-fr$

$\Rightarrow\ m\times2g=4mg-fr\ \Rightarrow\ fr=2mg$

$\mu R=2mg\ \Rightarrow\ \mu\cdot mg=2mg\ \Rightarrow\ \mu=2$

(d) for the system : $2ma=F$



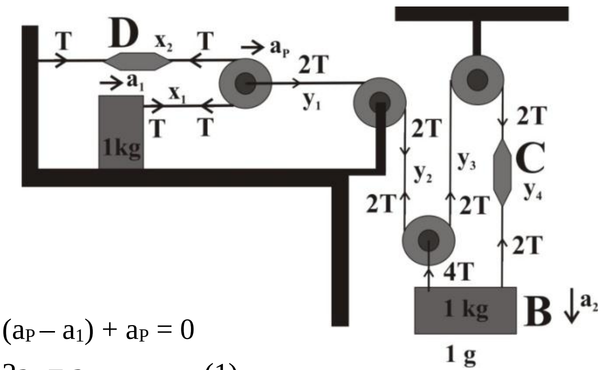
$\Rightarrow\ a=\frac{F}{2m}=\frac{4mg}{2m}=2g$ …….. (1)

For body A :

$ma=fr\ \Rightarrow\ m2g=fr\ \Rightarrow\ fr=2mg$

$\mu R=2mg\ \Rightarrow\ \mu mg=2mg\ \Rightarrow\ \mu=2$

Q17. $x_1+x_2=l_1$



$(a_P-a_1)+a_P=0$

$2a_P=a_1$ ………… (1)

$y_1+y_2+y_3+y_4=l_2$

$a_P+a_2+a_2+a_2=0\ \Rightarrow\ a_P=3a_2$ ………… (2)

from (1) & (2) : $2(3a_2)=a_1\ \Rightarrow\ 6a_2=a_1$ …..(3)

If $a_2=a,\ a_1=6a$

for body A : $1\times6a=T$ ………… (4)

for body B :

$1\times a=1g-4T-2T\ \Rightarrow\ a=g-6T$ ……….(5)

$(4)\times6+(5)$: $37a=g\ \Rightarrow\ a=g/37$

acc. of A : $a_1=6a=6g/37$;

acc. of B : $a_2=a=g/37$

from eq. (4) :

$6a=T\ \Rightarrow\ T=6\times g/37=6g/37$

Reading in C : $2T=2(6g/37)=12g/37$

Reading in D : T = 6g/37