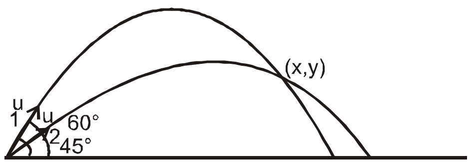
PHYSICS

1. For particle -1 $y = \sqrt{3}\,x - \dfrac{gx^2}{2u^2(1/4)} \Rightarrow y = \sqrt{3}\,x - \dfrac{2gx^2}{u^2}$

For particle-2 $y = x - \dfrac{gx^2}{2u^2(1/2)} \Rightarrow y = x - \dfrac{gx^2}{u^2}$



$x - \dfrac{gx^2}{u^2} = \sqrt{3}\,x - \dfrac{2gx^2}{u^2}$

$x(\sqrt{3}-1) = \dfrac{gx^2}{u^2} \Rightarrow x = \dfrac{u^2}{g}(\sqrt{3}-1)$

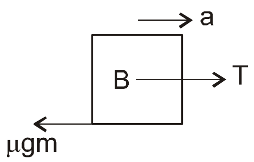
for particle -1

$u(1/2)\,t_1 = \dfrac{u^2}{g}(\sqrt{3}-1) \Rightarrow t_1 = \dfrac{2u}{g}(\sqrt{3}-1)$

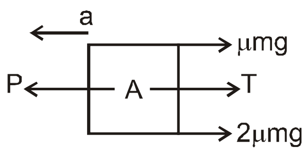
$u(1/\sqrt{2})\,t_2 = \dfrac{u^2}{g}(\sqrt{3}-1) \Rightarrow t_2 = \dfrac{\sqrt{2}u}{g}(\sqrt{3}-1)$

$\Delta t = u/g\ (2-\sqrt{2})(\sqrt{3}-1) = 10.9 \text{ sec} \simeq 11 \text{ sec.}$

2. **Case-I**

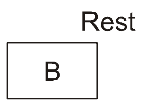


$T - \mu mg = ma$ .... (1)



$P - T - 3\,\mu mg = ma$
puting value of T from (1)
$P - ma - \mu mg - 3\mu mg = ma$
$P - 4\,\mu mg$
$a = -\,2\mu g$ .... (2)

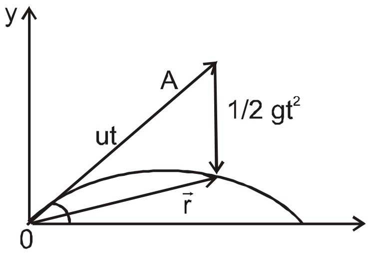
Case-II



$a = \dfrac{P - 3\mu mg}{m}$ .... (3)

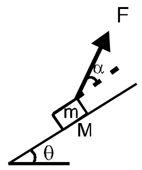
According to Q.
accelaration is same in both cases
Hence equating the equation (2) & (3)
$P = 2\mu mg$

3.



AB = 1/2 g(T/2)^2 = 1/8 gT^2
CD = 1/2 gT^2
CD/AB = 4

4.



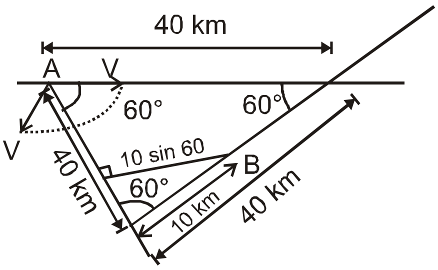
$F\cos\alpha - \mu N - mg\sin\theta = 0$ .... (i)
& $N + F\sin\alpha - mg\cos\theta = 0$ .... (ii)
Solving (i) & (ii)

$$F = \frac{mg\sin\theta + \mu mg\cos\theta}{\cos\alpha + \sin\alpha}$$

$$F_{min} = \frac{mg\sin\theta + \mu mg\cos\theta}{\sqrt{1+\mu^2}}$$ **Ans**

& $\tan\alpha = \mu \Rightarrow \alpha = \tan^{-1}\mu$ **Ans**

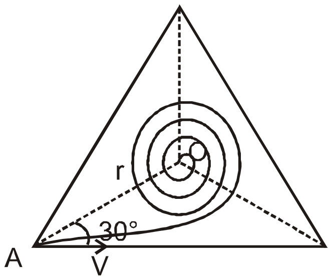
5.

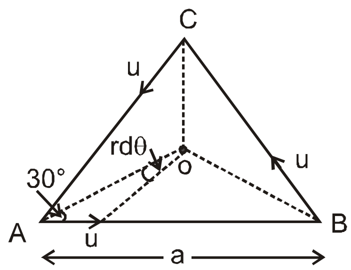


Let consider B as observer

d_{min} = 10 sin 60 km = $5\sqrt{3}$

6.





$$\frac{dr}{dt} = -v\cos 30° = -\frac{\sqrt{3}}{2}V$$

$$r\frac{d\theta}{dt} = v\sin 30° = v/2$$

$$\frac{1}{r}\frac{dr}{d\theta} = -\sqrt{3}$$

$$\int_{r_0}^{r}\frac{dr}{r} = -\sqrt{3}\int_0^{\theta}d\theta \Rightarrow r = r_0 e^{-\sqrt{3}\theta}$$

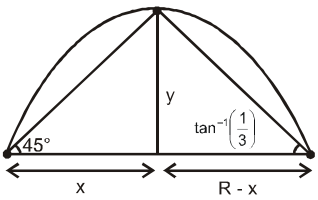
When A completes one revolution $\theta = 2\pi$

Time taken $t = \dfrac{r_0(1-e^{-2\sqrt{3}\pi})}{\sqrt{3}v/2}$

Distance travelled $D = vt = \dfrac{2r_0}{\sqrt{3}}(1-e^{-2\sqrt{3}\pi})$

$$D = \frac{2a}{3}(1-e^{-2\sqrt{3}\pi})$$

7. equation $y = x\tan\theta\left(1-\frac{x}{R}\right)$



at B $x = y$

$\tan\theta = \frac{R}{R-y}$ ..... (i)

$\tan 45° = \frac{y}{x}$

$x = y$ ..... (ii)

$\left(\frac{1}{3}\right) = \frac{y}{R-x}$ ..... (iii)

Solving equation 2 and 3

$R = 4y = 4x$ Put in (i)

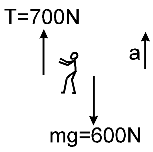
$\tan\theta = \frac{R}{R-\frac{R}{4}}$

$\tan\theta = \frac{4}{3}$

$\theta = 53°$

8. For student A to just lift off the floor, tension T in string must be greater than or equal to 700 N.

The F.B.D. of student B is



Applying Newton's second law

$T - mg = ma \Rightarrow 700 - 600 = 60\,a$

or $a = \frac{5}{3}$ m/s^2

9. The magnitude of the force (from the string) is T = 30N.

The x-component = T $\sin\theta$ = 30 × 3/5 = 18N.

The y-component = T $\cos\theta$ = 30 × 4/5 = 24N.

The total force on the block is:

the x-component = 18N.

the y-component = 24 – mg = 24 – 20 = 4N.

The x-component of the acceleration = 18N/2kg = 9m/s^2.

The y-component of the acceleration = 4N/2kg = 2m/s^2.

10. If stone always moves away from thrower then

$\Rightarrow \frac{d|\vec{r}|}{dt} > 0$

$\Rightarrow \vec{r}\cdot\vec{v} > 0 \quad \vec{r} = u\cos\theta\, t\,\hat{i} + \left(u\sin\theta\, t - \frac{1}{2}gt^2\right)\hat{j}$

$\vec{v} = u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j}$

$\vec{r}\cdot\vec{v} = u^2t - \frac{3}{2}\,ug\sin\theta\, t^2 + \frac{g^2}{2}\,t^3 > 0$

$\Rightarrow \frac{g^2}{2}t^2 - \frac{3}{2}\,ug\sin\theta\, t + u^2 > 0$

$\sin^2\theta < \frac{8}{9} \Rightarrow \theta < \sin^{-1}\left(\frac{2\sqrt{2}}{3}\right)$

11. Let total distance travelled is 4s.

$2s \rightarrow V_1 \rightarrow t_1 = \dfrac{2s}{V_1}$

$s \rightarrow V_2 \rightarrow t_2 = \dfrac{s}{V_2}$

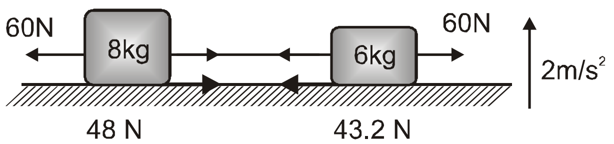
$s\begin{bmatrix} V_1 \rightarrow t_0 \\ V_2 \rightarrow t_0 \end{bmatrix}$ $\qquad (V_1 + V_2)\, t_0 = s \Rightarrow t_0 = \dfrac{s}{V_1 + V_2}$

$$< V > = \frac{4s}{t_1 + t_2 + 2t_0} = \frac{4s}{\frac{2s}{V_1} + \frac{s}{V_2} + \frac{2s}{V_1 + V_2}}$$

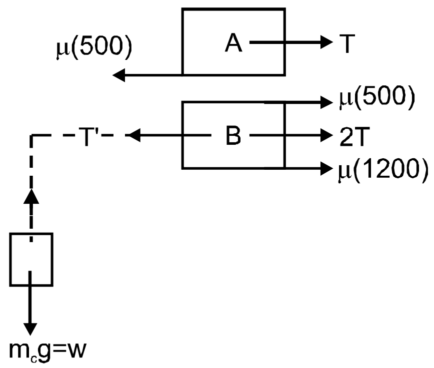
$$= \frac{4V_1V_2(V_1 + V_2)}{2V_2(V_1 + V_2) + V_1(V_1 + V_2) + 2V_1V_2}$$

$$= \frac{4V_1V_2(V_1 + V_2)}{2V_1V_2 + 2V_2^2 + V_1^2 + V_1V_2 + 2V_1V_2} = \frac{4V_1V_2(V_1 + V_2)}{V_1^2 + 2V_2^2 + 5V_1V_2}$$

12. f_R for 8 kg = 0.5 × 8(10 + 2) = 48 N
f_R for 6 kg = 0.6 × 6 (10 + 2) = 43.2 N
It can be verified that limiting friction will act on 6 kg
From FBD, tension = 16.8 N



13.



$3T + 0.3 \times 1200 = m_cg = W$ and $T = \mu(500) = 0.3 \times 500$
$W = m_0g = 810$ N.

14. For motion between AB

$$ma = mg \sin\alpha - \frac{\tan\alpha}{2} mg \cos\alpha$$

$$a = \frac{g\sin\alpha}{2} \text{(downward)}$$

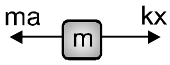
For motion between BO

$$ma = \frac{3\tan\alpha}{2} mg\cos\alpha - mg\sin\alpha$$

$$a = \frac{g\sin\alpha}{2} \text{(upward)}$$

The velocity increases from zero to maximum value at B and then starts decreasing with same rate and finally becomes zero at O.

15. $mv\frac{dv}{dx} = ma - kx$

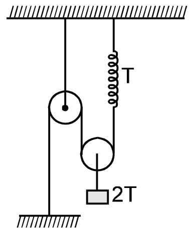


$$\int_0^0 mvdv = \int_0^x (ma - kx)dx$$

$$x = \frac{2ma}{k}.$$

17. Initially the block is at rest under action of force 2T upward and mg downwards. When the block is pulled downwards by x, the spring extends by 2x. Hence tension T increases by 2kx. Thus the net unbalanced force on block of mass m is 4kx.

$\therefore$ acceleration of the block is = $\frac{4kx}{m}$



18. $mg - T = 2ma$ ....(i)

$2T - mg = ma$ ....(ii)

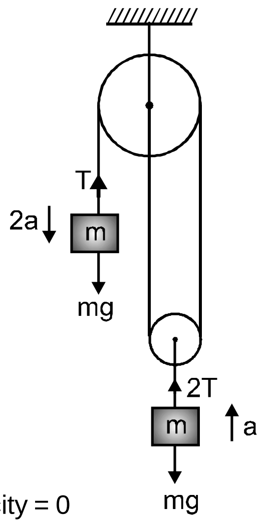
Solving,

$mg = 5\,ma$

$a = \frac{g}{5}$

$T = mg - 2ma$

$= mg - 2m\frac{g}{5} = \frac{3mg}{5}$.



19. **(i)** Relative initial velocity = 5 m/s, relative final velocity = 0

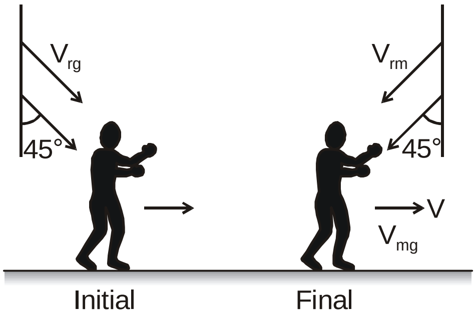
Relative displacement = 50 m

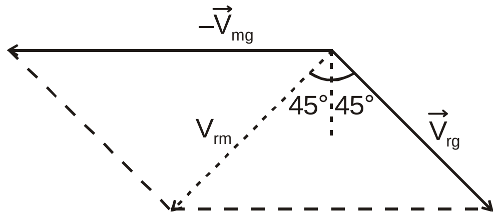
Relative acceleration = constant

$\Rightarrow$ $50 = \left(\frac{5+0}{2}\right)t$ $\Rightarrow$ t = 20 sec. **Ans.**

(ii) Distance of dead line from car $C_1 = \left(\frac{25+0}{2}\right)\times 20$ = 250 m. **Ans.**

20.





$\vec{V}_{rg} = \vec{V}_{rm} + \vec{V}_{mg}$

$\vec{V}_{rm} = \vec{V}_{rg} - \vec{V}_{mg}$

$V_{rm} \cos 45° = V_{rg} \cos 45°$

$V_{rm} = 2\sqrt{2}$ m/s $= V_{rg}$

$V_{rm} \cos 45° = V_{mg} - V_{rg} \cos 45°$

$V_{mg} = 2\sqrt{2}\frac{1}{\sqrt{2}} + 2\sqrt{2}\frac{1}{\sqrt{2}} = 4$ m/s

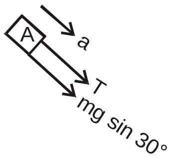
using $v^2 = u^2 + 2as$ for the motion of man,

s = 16 m.

21. Let a be acceleration of system and T be tension in, the string.

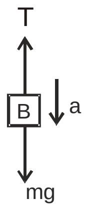
F.B.D of block A

mg sin 30° + T = ma



$\frac{mg}{2} + T = ma$ ..... (i)

F.B.D of block B



mg – T = ma ..... (ii)

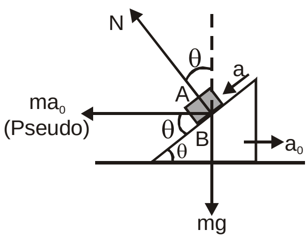
Adding equation (i) & (ii); we get

$2ma = \frac{3mg}{2} \Rightarrow a = \frac{3}{4}g$

from equation (i);

$T = \frac{mg}{4}$

22.



$ma_0 \sin\theta + N = mg \cos\theta \Rightarrow N = mg\cos\theta - ma_0\sin\theta$

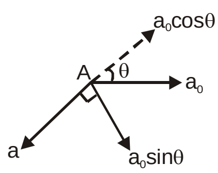
$\Rightarrow N < mg \cos\theta$

Hence, (D) is true.

$ma_0 \cos\theta + mg \sin\theta = ma$

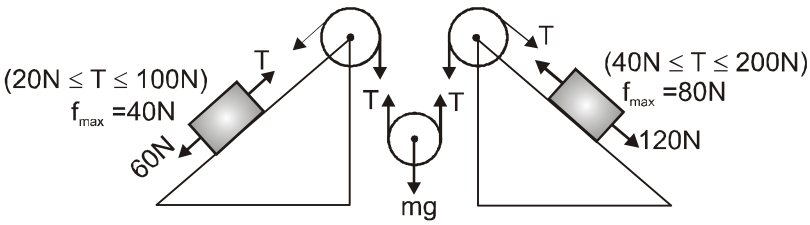
$\Rightarrow a = g \sin\theta + a_0 \cos\theta$

Hence acceleration of A



$= \sqrt{(a - a_0 \cos\theta)^2 + (a_0 \sin\theta)^2} > g\sin\theta$.

23. $T = \dfrac{mg}{2}$

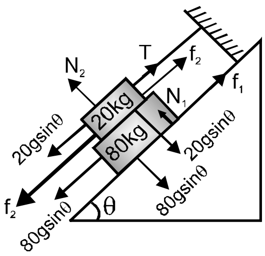


For the equilibrium of 10kg block tension in string should be between 20 N to 100 N, while for the equilibrium of 20 kg range of tension is 40 N to 200 N, so for the equilibrium of system, tension in the string must be between 40 N to 100 N and mass of block must be between 8 kg to 20 kg.

24. $20g\sin\theta + f_2 = T$

$20g\sin\theta + \mu(20g\cos\theta) = T$

$80g\sin\theta = \mu(100g\cos\theta) + \mu(20g\cos\theta)$



$\tan\theta = \dfrac{3}{8}$

$T = 20g\sin\theta + \mu\, 20g\cos\theta$

$= 20g\sin\theta + \dfrac{1}{4} \times 20 \times g \times \dfrac{8}{3}\sin\theta$

$= \left(\dfrac{100}{3} g\sin\theta\right) N$

Net friction on 80 kg $= f_1 + f_2 = 80\, g\sin\theta$

force on 80 kg due to 20 kg is $\sqrt{(20g\cos\theta)^2 + (\mu 20g\sin\theta)^2}$ ..

25. Impulse $= \int \vec{F}dt = m(\vec{v}_f - \vec{v}_i)$

$-mg \times$ Area under $\mu - t$ graph $= m\,(v_f - 20.5)$

$-mg \times \left[\dfrac{1}{2}(0.4+0.3)\times 1 + 0.4\times 2 + \dfrac{1}{2}(0.4+0.2)\times 1\right] = m(v_f - 20.5)$

$v_f = 6$m/s

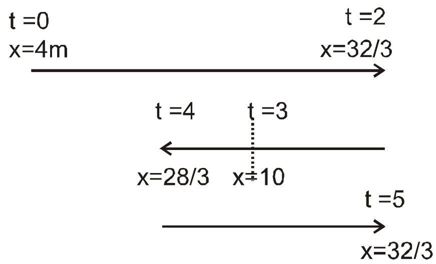
26. $x = t^3/3 - 3t^2 + 8t + 4$

$v = t^2 - 6t + 8 = (t-2)(t-4)$

$a = 2(t-3)$

		2	3	4
V	+	–	–	+
a	–	–	+	+

$S_1 = \left(\dfrac{32}{3} - 4\right) + \left(\dfrac{32}{3} - \dfrac{28}{3}\right) + \left(\dfrac{32}{3} - \dfrac{28}{3}\right) = \dfrac{20}{3} + \dfrac{8}{3} = \dfrac{28}{3}$ m.



$S_2 = \left(\dfrac{32}{3} - 4\right) + \left(10 - \dfrac{28}{3}\right) = \dfrac{20}{3} + \dfrac{2}{3} = \dfrac{22}{3}$ m

$\dfrac{S_1}{S_2} = \dfrac{28}{22} = \dfrac{14}{11} = \dfrac{3\alpha + 2}{11} \Rightarrow \alpha = 4$

27. The block begins to slide if

F cos 37° = μ (mg – F sin 37°)

5t [cos 37° + μ sin 37°] = μ mg

$5t\left[\frac{4}{5}+\frac{3}{5}\right] = 70$ or t = 10 second

28. Taking block + wedge as system and applying NLM in horizontal direction

$f_2 = m_1 a \cos\theta$

$= m_1 [g(\sin\theta - \mu_1 \cos\theta)] \cos\theta$ .... (1)

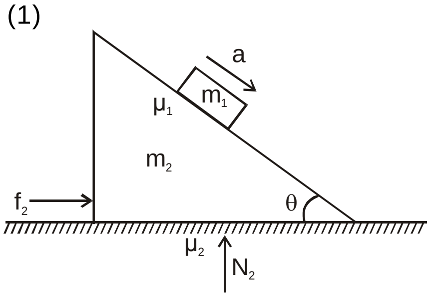
Again applying NLM in vertical direction

$(m_1 + m_2)g - N_2 = m_1 a \sin\theta$

$N_2 = (m_1 + m_2)g - m_1 \sin\theta(g \sin\theta - \mu_1 g \cos\theta)$

For limiting condition $f_2 = \mu_2 N_2$ .... (2)

From (1) and (2)



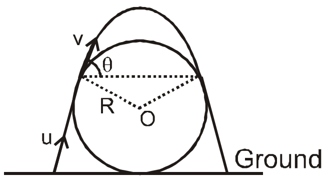
$$\mu_2 = \frac{m_1\cos\theta(g\sin\theta - \mu_1 g\cos\theta)}{(m_2 + m_2)g - m_1\sin\theta(gsn\theta - \mu_1 g\cos\theta)}$$

Using values

$\mu_2 = \frac{1}{8} = 125 \times 10^{-3}$

Ans. 125

29.



$$\frac{2v^2\sin\theta\cos\theta}{g} = 2R\sin\theta \Rightarrow v^2 = \frac{Rg}{\cos\theta}$$

$u^2 = v^2 + 2g\,R\,(1 + \cos\theta)$

$$u^2 = \frac{Rg}{\cos\theta} + 2gR + 2gR\cos\theta$$

$$u^2 = Rg\left(\frac{1+2\cos^2\theta}{\cos\theta}\right) + 2gR$$

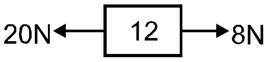
for u to be minimum $\frac{1+2\cos^2\theta}{\cos\theta}$ = min

$\Rightarrow$ $\cos\theta = \frac{1}{\sqrt{2}}$ $\Rightarrow$ $\theta = \pi/4$

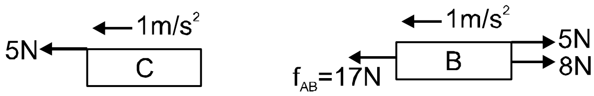
$u_{min} = \sqrt{\sqrt{2}Rg + 2gR + \sqrt{2}Rg} = \sqrt{2gR\,(\sqrt{2}+1)}$

30. Let everything moves together

Then,



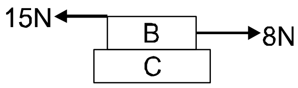
a = $\frac{12}{12}$ = 1 m/s^2



But $f_{AB\ maximum}$ = 15N

So, sliding occurs.

Now, see if B and C move together.



a = $\frac{15-8}{9}$ = $\frac{7}{9}$ m/s^2

So, friction acting between B and C is $\frac{7}{9}$ × 5 m/s^2.

31. a = b + c

Net acceleration of A = $\sqrt{a^2+c^2+2ac\cos(\pi-\theta)}$ = $\sqrt{(b+c)^2+c^2-2(b.+c).c.\cos\theta.}$ = $\sqrt{3}$

33. For block B. ;

$2ma_B = F - \frac{mg}{2}$

$a_B = g$

For block A ;

$ma_A = mg$

$a_A = g/2$

$a_{AB} = -g/2$

$L = \frac{1}{2}\frac{g}{2}.t_1^2$

$t_1 = \sqrt{\frac{2}{5}}s$

time of flight $t_2 = \sqrt{\frac{2h}{g}} = \frac{1}{\sqrt{10}}s$

Velocity when A leaves B. ;

$V_A = g/2\ t_1 = g/2 \times \sqrt{\frac{4L}{g}} = \sqrt{10}$ m/s

$S_x = V_A t_2 = 1m$

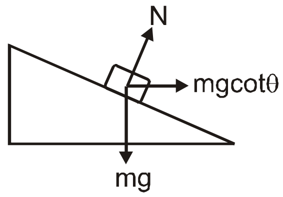
$S_y = \frac{1}{2}\frac{g}{2}\frac{2h}{g} = \frac{1}{4}m$

$\frac{S_x}{S_y} = 4$

$\vec{a}_A = \frac{g}{2}\hat{j} - g\hat{k}$

$\vec{a}_B = \frac{5g}{4}\hat{i}, |\vec{a}_{AB}| = \left(\sqrt{\frac{1}{4}+1+\frac{25}{16}}\right)g$

34 to 36. If we draw FBD of block w.r.t wedge



$N + F_s \sin\theta = mg \cos\theta$

$\Rightarrow$ $N = 0$

so w.r.t ground block will fall freely.

$h = \frac{1}{2}gt^2$ and $h = \ell \sin\theta$

37. to 39

From conservation of momentum

$3mv = mu$ or $v = \frac{u}{3}$

Net workdone by friction = $\frac{1}{2}3m\left(\frac{u}{3}\right)^2 - \frac{1}{2}mu^2 = -\frac{1}{3}mu^2$

net work done by friction = $\int_{\ell}^{0} \mu(x\lambda g)(-dx) = -\mu\lambda g \frac{L^2}{2}$

Also magnitude of net work done by friction = $\mu\lambda g \frac{L^2}{2} = \mu mg \frac{L}{2}$

$\therefore \frac{1}{3}mu^2 = \mu mg \frac{L}{2}$ or $\mu = \frac{2}{3}\frac{u^2}{gL}$

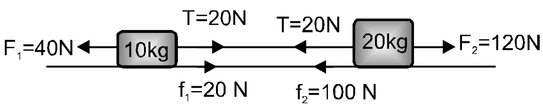
$3mv = mu$ or $v = \frac{u}{3}$

40. $\left|\vec{F}_1 + \vec{F}_2\right| < |f_1|_{max} + |f_2|_{max}$

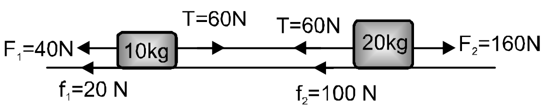
So, both blocks not move in any case.

$|f_1|_{max} = 50$ N ; $|f_2|_{max} = 100$ N

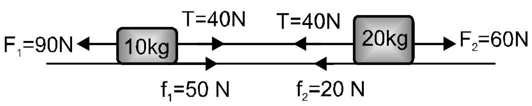
(A)



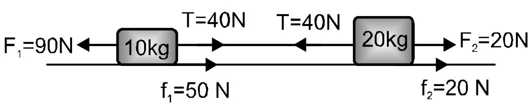
(B)



(C)



(D)



41. $\vec{V}_{P,P} = V_2\hat{i} + 25\hat{j} + V_1\hat{k}$

$\vec{a}_{P,P} = -2\hat{i} - 12.5\hat{j}$

$\vec{V}_{P,P}$ = Velocity of particle relative to platform

Time $= \dfrac{2 \times 25}{12.5}$ = 4 sec.

$8 \le V_2 \times 4 - \dfrac{1}{2} \times 2 \times 4^2 \le 16$

$6 \le V_2 \le 8$

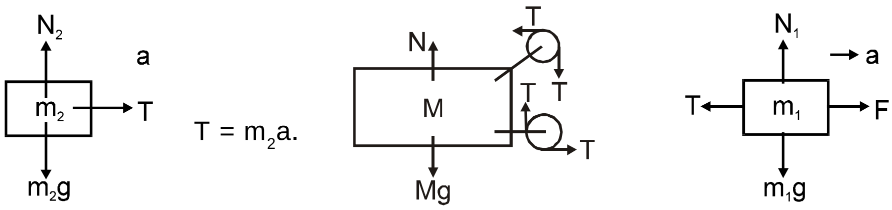
$16 \le V_1 \times 4 \le 24$

$4 \le V_1 \le 6$

$Y = 25 \times 4 - \dfrac{1}{2} \times 10 \times 4^2 = 100 - 80 = 20\text{m}$

42. (A) Q (b) Q (C) R (D) S

FBD's



$F - T = m_1a$

$F = (m_1 + m_2)a$

$\because \quad T = m_2a$

$\Rightarrow \quad a = \dfrac{F}{m_1 + m_2}$ $\quad \because T = \dfrac{m_2F}{m_1 + m_2}$. $\quad F_x = 0,\ a_M = 0$