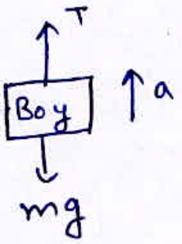
Exercise Level 1

①



$T - mg = ma$

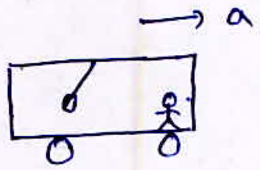
$T_{max} = 750\ N$

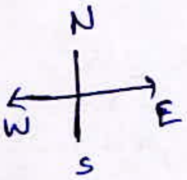
$T_{max} - mg = m\, a_{max}$

$750 - 600 = 60\, a_{max}$

$a_{max} = \frac{150}{60} = 2.5\ m/s^2$

②





From observers frame of ref.

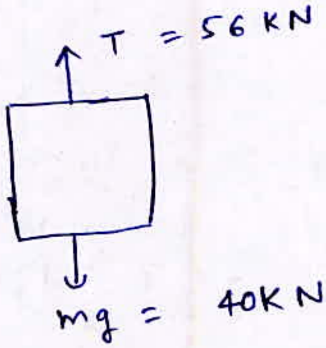
pseudo force $= -ma$

$-ma = -0.1 \times 5$

$= -0.5\ N$

$0.5\ N$ towards left

③



$T - mg = ma$

$56\ KN - 40\ KN = 4 \times 10^3 \times a$

$a = 4\ m/s^2$

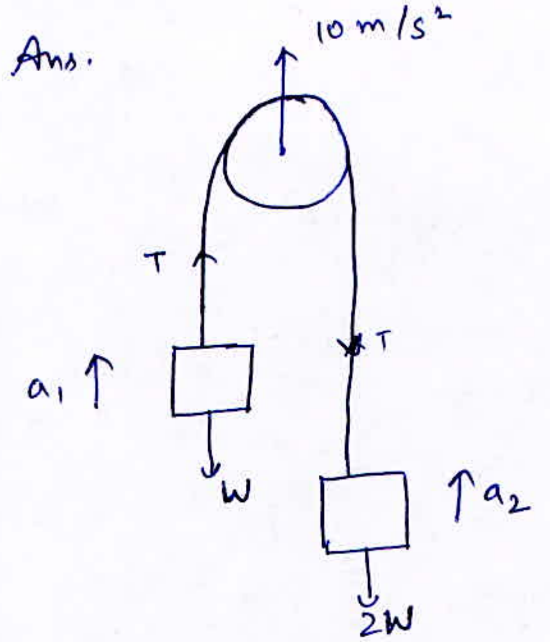
$s = ut + \frac{1}{2} a t^2$

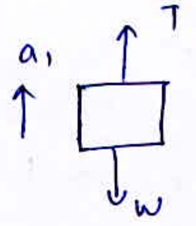
$= 0 \times 2 + \frac{1}{2} \times 4 \times 2^2$

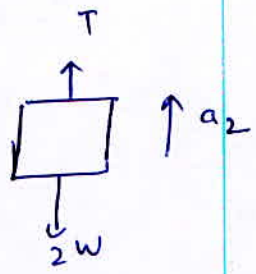
$= 8\ m$

Q 4.

Ans.







$$T - W = \frac{W}{g} a_1 \quad — ①$$

$$T - 2W = \frac{2W}{g} a_2 \quad — ②$$

$$\frac{a_1 + a_2}{2} = 10$$

$$a_1 + a_2 = 20 \quad — ③$$

eq ① × 2 + eq ②

$$3T - 4W = \frac{2W}{g}(a_1 + a_2)$$

$$3T - 4W = \frac{2W}{g} \times 20$$

$$3T - 4W = 4W$$

$$T = \frac{8W}{3}$$

⑤

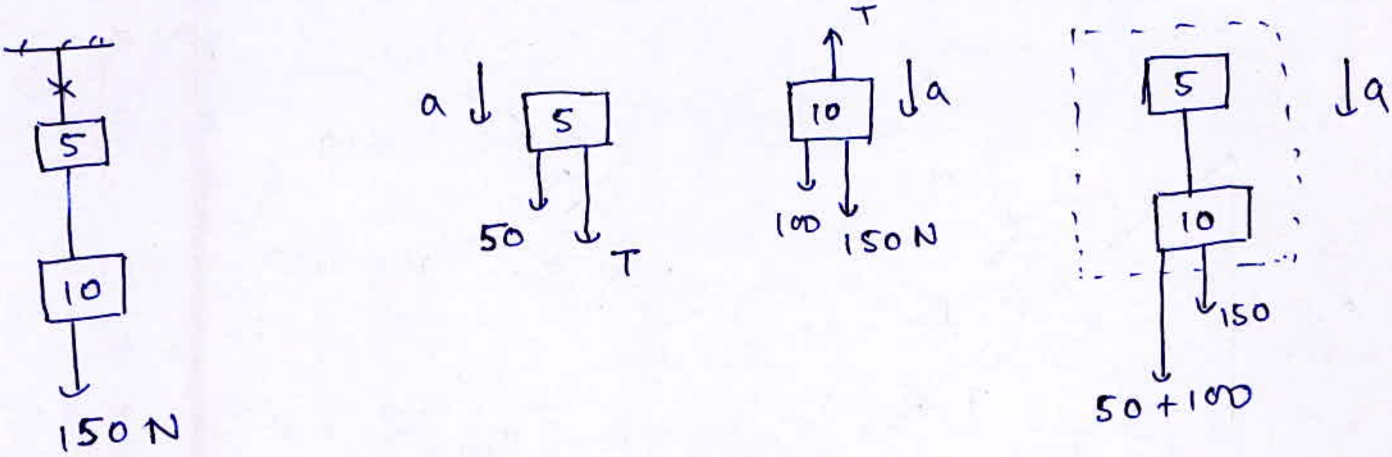
Force exerted on machine gun $= -n\left(\begin{array}{c}\text{Force exerted} \\ \text{on one bullet}\end{array}\right)$

$$F_{bullets} = n(mv - 0)$$

$$= mvn$$

$F_{machine\ gun} = -mvn \equiv mvn$ in opposite dirn.

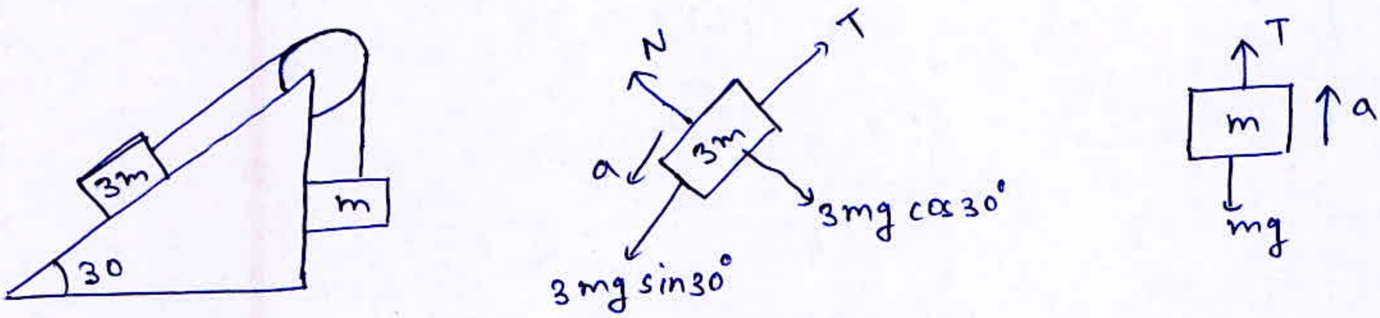
6



$$150 + 150 = 15 \times a$$

$$a = 20\, m/s^2$$

7



$$3mg \sin 30^\circ - T = 3m\,a \quad - (1)$$

$$T - mg = m\,a \quad - (2)$$

(1) + (2)

$$\frac{mg}{2} = 4m\,a$$

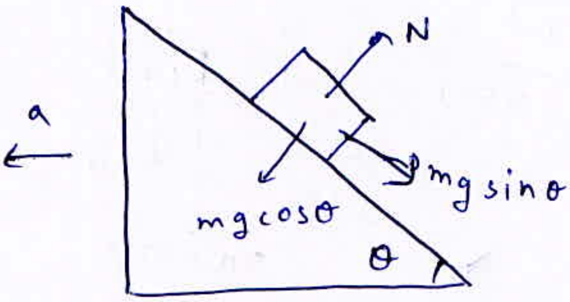
$$a = g/8$$

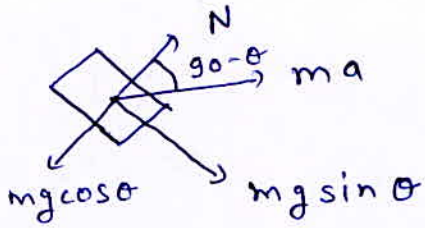
from eq (2)

$$T = mg + \frac{mg}{8}$$

$$= \frac{9mg}{8}$$

(8)





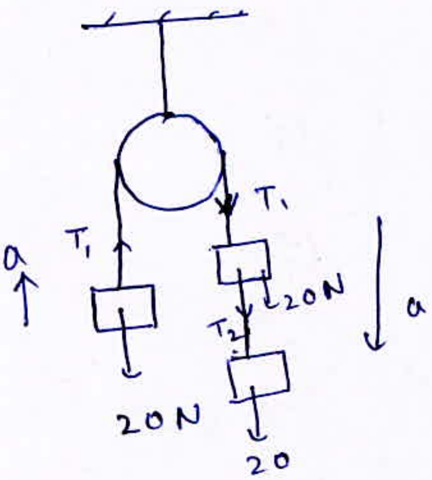
$N + \cancel{mg}\ ma\sin\theta = mg\cos\theta$

for free fall $\quad N = 0$

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

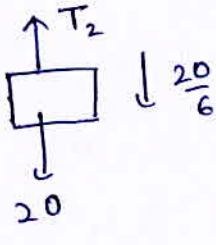
$a = g\cot\theta$

(9)



$(20 + 20 - 20)\,N = 6a$

$a = \frac{20}{6}\ m/s^2$

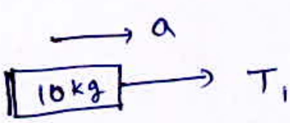


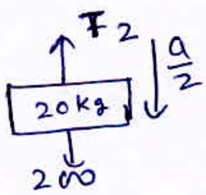
$20 - T_2 = 2 \times \frac{20}{6}$

$T_2 = 20 - \frac{20}{3}$

$= 13.3\ N$

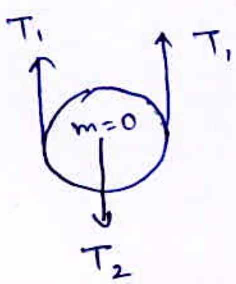
(10)





$200 - T_2 = 20 \times \frac{a}{2}$ — (1)

$T_1 = 10a$ — (2)



$2T_1 - T_2 = 0$

$T_2 = 2T_1$ — (3)

from (1), (2) & (3)

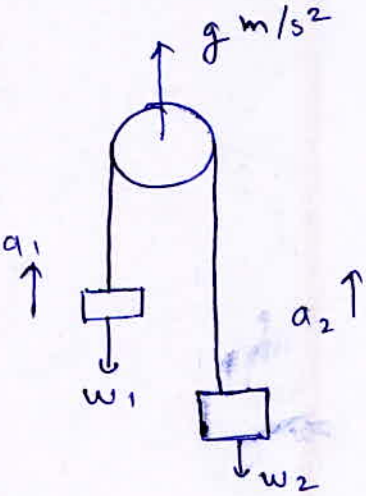
$200 - 20a = 10a$

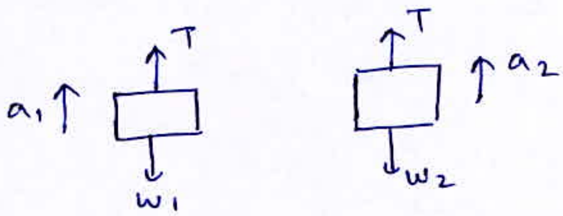
$a = \frac{20}{3}\ m/s^2$

$\boxed{\frac{a}{2} = \frac{10}{3}\ m/s^2\ \text{Ans}}$

(11)

$$\frac{a_1 + a_2}{2} = g$$





$$T - w_1 = \frac{w_1}{g} a_1 \quad -①$$

$$T - w_2 = \frac{w_2}{g} a_2 \quad -②$$

multiply ① with w_2 & ② with w_1 and add

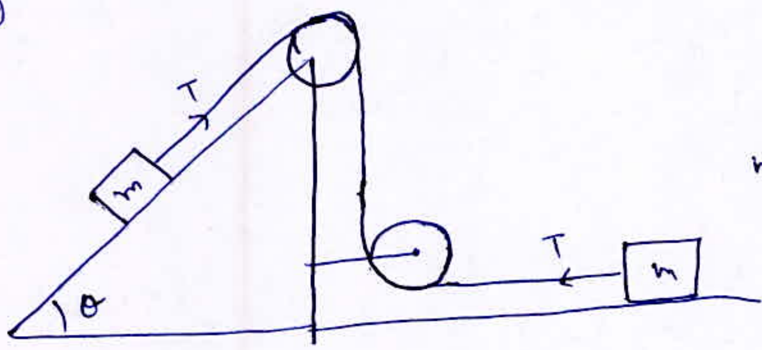
$$(w_1 + w_2) T - 2 w_1 w_2 = \frac{w_1 w_2}{g} (a_1 + a_2)$$

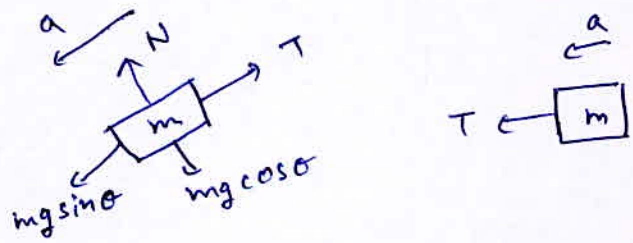
$$(w_1 + w_2) T - 2 w_1 w_2 = \frac{w_1 w_2}{\cancel{g}} \times 2\cancel{g}$$

$$\boxed{T = \frac{4 w_1 w_2}{w_1 + w_2}}$$

Ans.

(12)





$$T = ma \quad -①$$

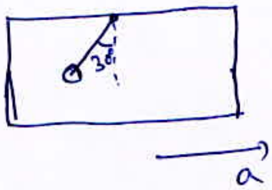
$$mg\sin\theta - T = ma \quad -②$$

from ① & ②

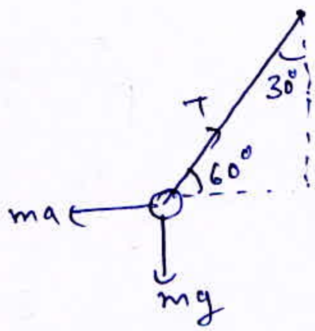
$$\boxed{T = \frac{mg\sin\theta}{2}}$$

Ans.

Q 13.



in the frame of carriage



$$T\sin 60^\circ = mg$$

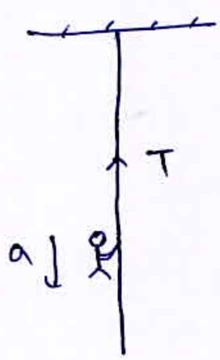
$$T = \frac{2mg}{\sqrt{3}}$$

$$T\cos 60^\circ = ma$$

$$\frac{\cancel{2}\cancel{m}g}{\sqrt{3}} \times \frac{1}{\cancel{2}} = \cancel{m}a$$

$$\boxed{a = \frac{g}{\sqrt{3}}}$$ Ans.

Q 14
Ans.



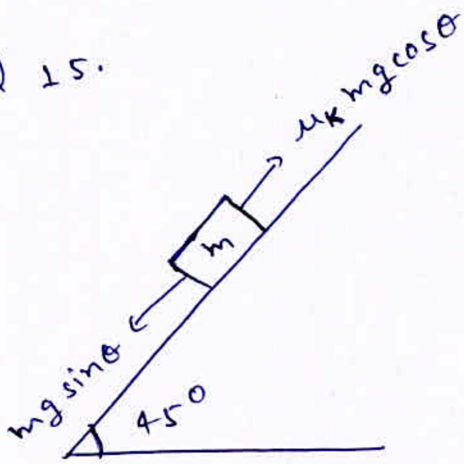
$$mg - T = ma$$

$$T \leq \frac{2mg}{3}$$

$$mg - \frac{2mg}{3} = ma$$

$$\boxed{a = \frac{g}{3}}$$ Ans.

Q 15.



when rough inclined plane

$$s = \frac{1}{2}\left(g\sin\theta - \mu_K g\cos\theta\right)(2t)^2$$

$$s = 2g t^2\left(\sin\theta - \mu_K\cos\theta\right) \quad -(1)$$

when smooth

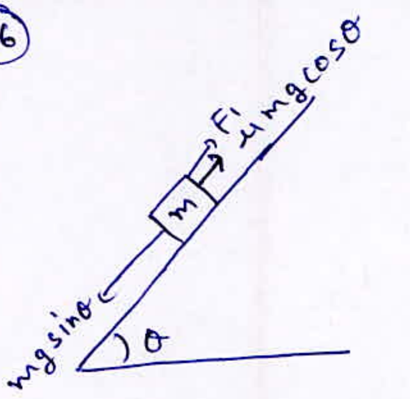
$$s = \frac{1}{2} g\sin\theta\, t^2 \quad -(2)$$

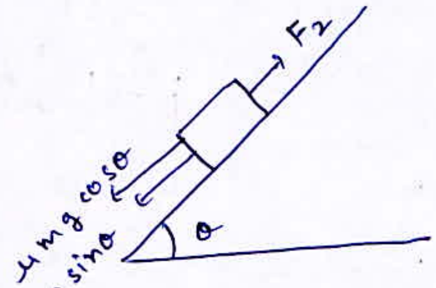
from (1) & (2)

$$2\cancel{g}\cancel{t^2}\left(\sin\theta - \mu_K\cos\theta\right) = \frac{1}{2}\cancel{g}\sin\theta\,\cancel{t^2}$$

$$\frac{3}{2}\sin\theta = 2\mu_K\cos\theta \Rightarrow \boxed{\mu_K = \frac{3}{4}}$$ Ans.

Q (16)





moving down   moving up

$F_2 = 2F_1$

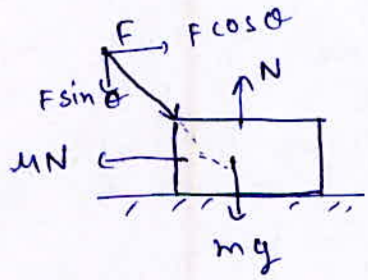
$$mg\sin\theta + \mu mg\cos\theta = 2(mg\sin\theta - \mu mg\cos\theta)$$

$$3\mu mg\cos\theta = mg\sin\theta$$

$$\tan\theta = 3\mu$$

$$\boxed{\theta = \tan^{-1}(3\mu)}$$

Q (17)



$$\tan\phi = \frac{\mu N}{N} = \mu \quad -(1)$$

$$N = mg + F\sin\theta$$

$$F\cos\theta = \mu(mg + F\sin\theta) \quad -(2)$$

from (1) & (2)

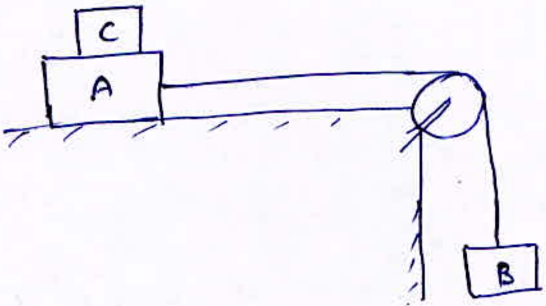
$$F\cos\theta = \frac{\sin\phi}{\cos\phi}\cdot(mg + F\sin\theta)$$

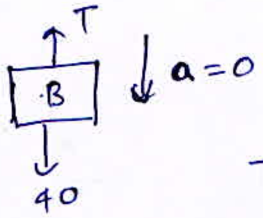
$$mg\sin\phi = F(\cos\theta\cos\phi - \sin\theta\sin\phi)$$

$$\boxed{F = \frac{mg\sin\phi}{\cos(\theta+\phi)}}$$

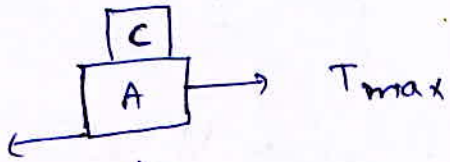
Ans.

Q (18)





$T_{max} = 40$ N

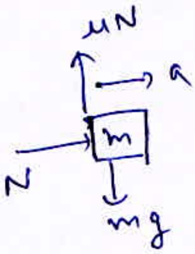


$T_{max} = \mu(m_A + m_c)\, g$

$40 = 0.4\,(6 + m_c) \times 10$

$\boxed{m_c = 4 \text{ kg.}}$

Q (19)

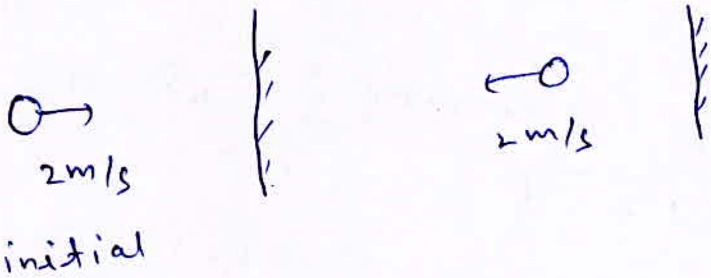


$N = ma$

$mg = \mu(ma)$

$\boxed{a = \frac{g}{\mu}}$

Q (20)



$F_{wall} = -F_{ball}$

$F_{ball} = \frac{mV_{final} - mV_{initi}}{\Delta t}$

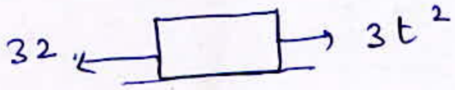
$= \frac{0.5 \times (-2) - 0.5(2)}{10^{-3}}$

$= -2 \times 10^{3}$ N

$\boxed{F_{wall} = 2000 \text{ N}}$ Ans.

(21.)

$v_i = 10 \text{ m/s}$



$F_{net} = 3t^2 - 32$

$a_{net} = \frac{3t^2}{10} - \frac{32}{10}$

$$\frac{dv}{dt} = \frac{3t^2}{10} - \frac{32}{10}$$

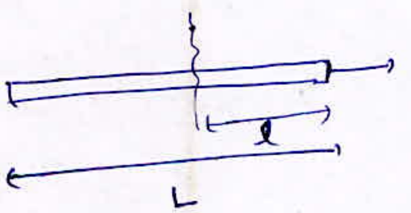
$$\int_{v_i}^{v_f} dv = \int_0^5 \left(\frac{3t^2}{10} - \frac{32}{10}\right) dt$$

$$v_f - 10 = \left[\frac{t^3}{10} - \frac{32t}{10}\right]_0^5$$

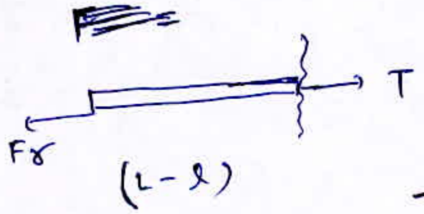
$$v_f = 12.5 - 16 + 10$$

$$\boxed{v_f = 6.5 \text{ m/s}}$$

(22)

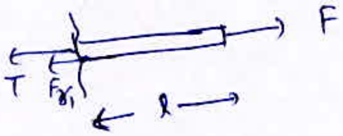


λ per unit mass



$T = Fr$

$T = \mu (L-l) \lambda g \quad -①$



$F = \mu \lambda L g \quad -②$

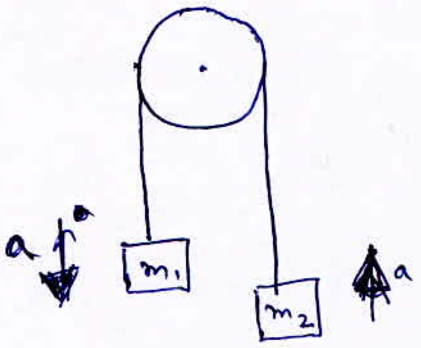
$$\boxed{T = \frac{F(L-l)}{L}}$$ Ans.

(23)

$v^2 = 0^2 + 2\mu g s$

$$\boxed{s = \frac{v^2}{2\mu g}}$$ Ans.

(24)



$$a = \frac{(m_1 - m_2)\, g}{m_1 + m_2}$$

$$1.4 = 0 + \frac{1}{2} a (2)^2$$

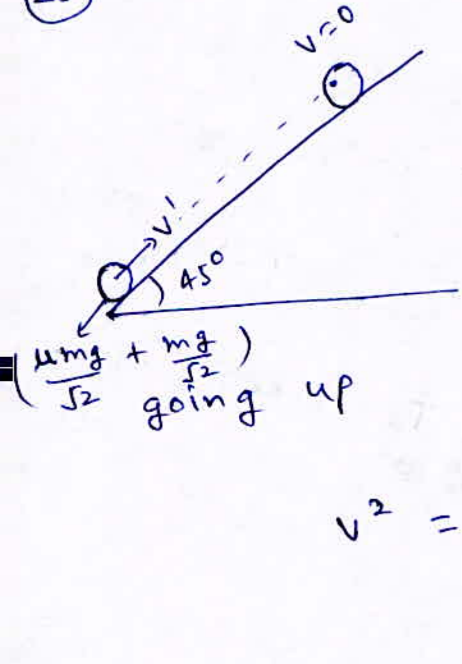
$$a = 0.7$$

$$0.7 m_1 + 0.7 m_2 = 9.8 m_1 - 9.8 m_2$$

$$10.5 m_2 \qquad 9.1 m_1$$

$$\boxed{m_1/m_2 = \frac{10.5}{9.1} = \frac{15}{13}}$$ Ans.

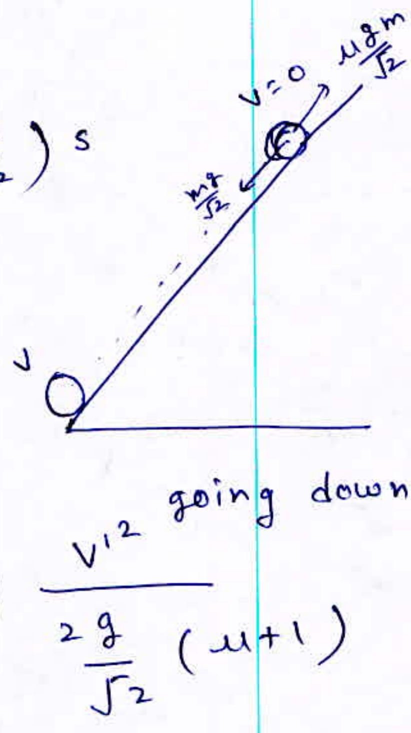
(25)



going up

$$0^2 = v'^2 - 2\left(\frac{\mu g}{\sqrt{2}} + \frac{g}{\sqrt{2}}\right) s$$

$$s = \frac{v'^2}{\frac{2g}{\sqrt{2}}(\mu+1)}$$



going down

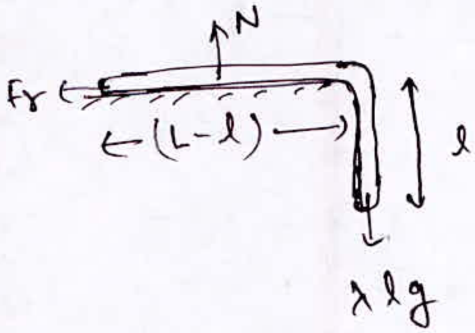
$$v^2 = 0^2 + 2\left(\frac{g}{\sqrt{2}} - \frac{\mu g}{\sqrt{2}}\right) \frac{v'^2}{\frac{2g}{\sqrt{2}}(\mu+1)}$$

$$= v'^2 \left(\frac{1-\mu}{\mu+1}\right)$$

$$= v'^2 \frac{1/2}{3/2} = \frac{v'^2}{3}$$

$$\sqrt{3} = \frac{v'}{v}$$

(26)



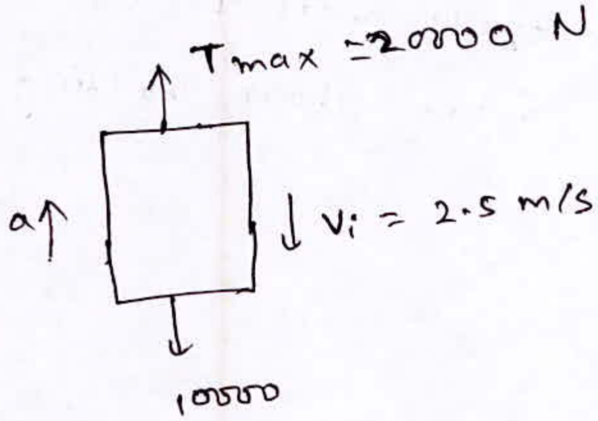
assuming λ kg/m is per unit length (mass of chain)

$$\lambda l g = F_r$$

$$\lambda l g = \mu \lambda (L-l) g$$

$$\boxed{l = \frac{\mu L}{\mu + 1}}$$

(27)



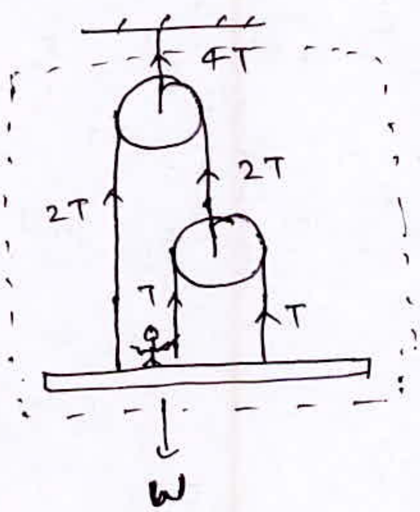
$$v_f^2 = v_i^2 - 2as$$

$$0 = (2.5)^2 - 2\left(\frac{20000 - 10000}{1000}\right)s$$

$$s = \frac{6.25 \times 10^3}{2 \times 10^4}$$

$$\boxed{s = \frac{6.25}{20} = \frac{5}{16}}$$

(28)



Net Force in y direction

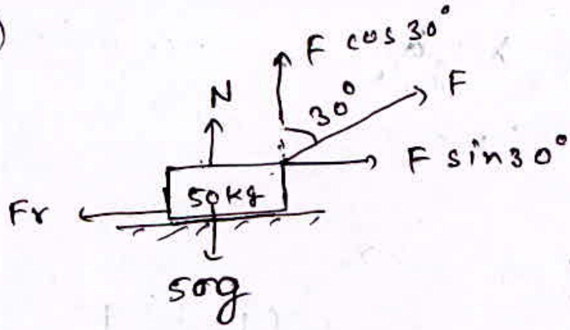
$$4T - W = m\cancel{a}^{\,0}$$

$$4T = W$$

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

$$\boxed{T = 15 \text{ kgf}}$$

(29)



$$N = 50g - \frac{\sqrt{3}F}{2} \quad -(1)$$

$$\mu N = \frac{F}{2} \quad -(2)$$

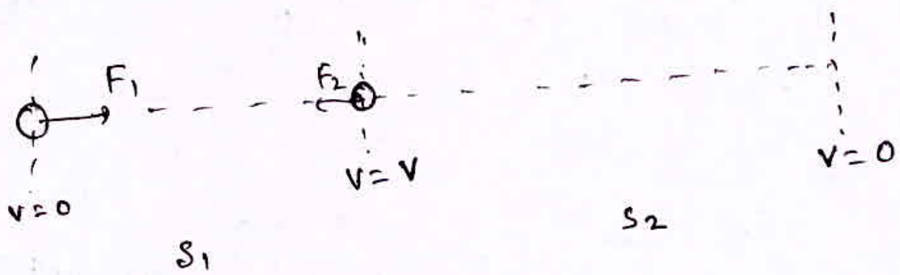
$$\mu\left(50g - \frac{\sqrt{3}}{2}F\right) = \frac{F}{2}$$

$$\boxed{F = 288.3\ N}$$ Ans.

(30)

It is difficult to move a cycle with brakes on because sliding friction is more than rolling friction.

(31)



$$a = \frac{F_1}{m}$$

$$v^2 = 0^2 + 2aS_1$$

$$v^2 = 2\frac{F_1}{m}S_1 \quad -(1)$$

$$0^2 = v^2 - 2\frac{F_2}{m}S_2$$

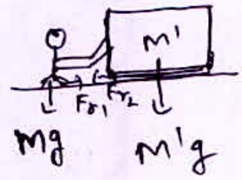
$$v^2 = 2\frac{F_2}{m}S_2 \quad -(2)$$

from (1) & (2)

$$\frac{F_1}{m}S_1 = \frac{F_2}{m}S_2$$

$$\frac{F_1}{F_2} = \frac{S_2}{S_1}$$ may be equal not necessary.

(32)



Net horizontal force

$$Fr_1 - Fr_2 = ma$$

for ~~[illegible]~~ sliding

$$Fr_1 > Fr_2$$

$$\mu M g > \mu' M' g$$

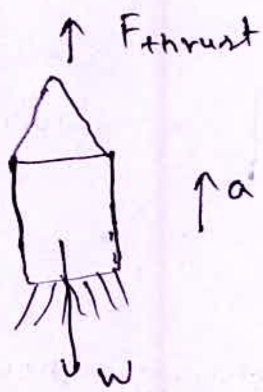
$$\mu M > \mu' M'$$

for not sliding

$$\mu M < \mu' M'$$

$$\boxed{\mu < \mu' , \quad M < M'}$$ Ans.

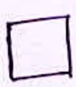
(33)



$$F_{thrust} - W = ma$$

F_{thrust} compensates for W

(34)



S_1

pseudo froce from S_1 = F_1

pseudo frorce from S_2 = F_2

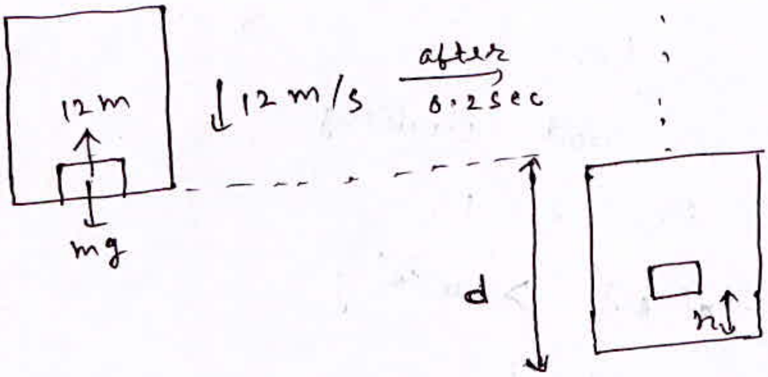
S_2 moves with respect to S_1 with acc. a

$$F_2 = F_1 + ma$$

if $F_1 = 0 \Rightarrow F_2 = ma$

not possible $\boxed{F_1 = 0 , \quad F_2 = 0}$ Ans.

(35)



displacement of block

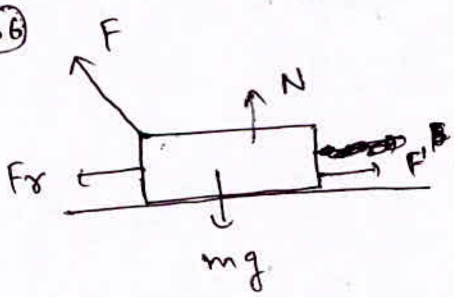
$= d - x$

$d = \frac{1}{2} \times 12 \times (0.2)^2$

$x = \frac{1}{2} \times 2 \times (0.2)^2$

$(d - x) = \frac{1}{2} \times 10 \times (0.2)^2 = \boxed{20 \text{ cm.}}$ Ans.

(36)



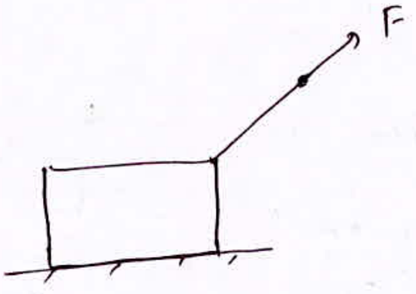
$N = mg$

$0 \leq Fr \leq \mu N = \mu mg$

$F = \sqrt{N^2 + (\mu N)^2}$

$\boxed{mg \leq F \leq mg\sqrt{\mu^2 + 1}}$ Ans.

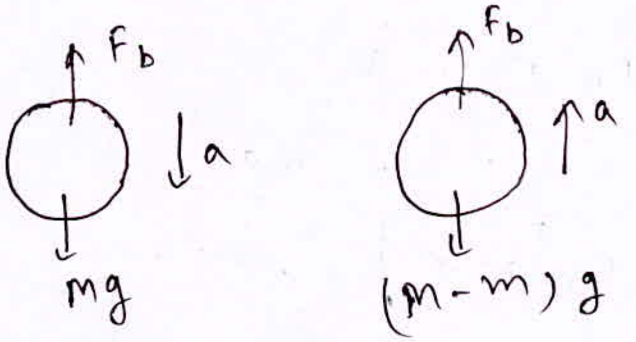
(37)



force on string should be along the string

(perpendicular component = 0)

(38)

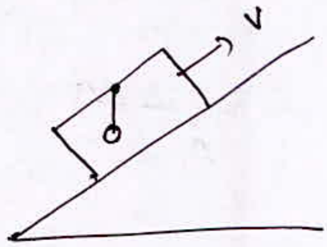


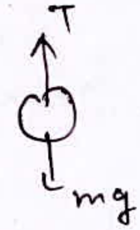
$mg - F_b = Ma$ —(1)

$F_b - (M - m) g = (M - m) a$ —(2)

$m = \left(\frac{2a}{g + a}\right) M$

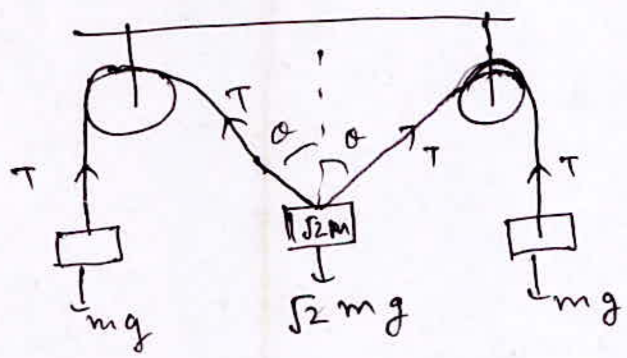
(39)





vertical

(40)



$T = mg$

$2T\cos\theta = \sqrt{2}\,mg$

$2\,mg\cos\theta = \sqrt{2}\,mg$

$\cos\theta = \frac{1}{\sqrt{2}}$

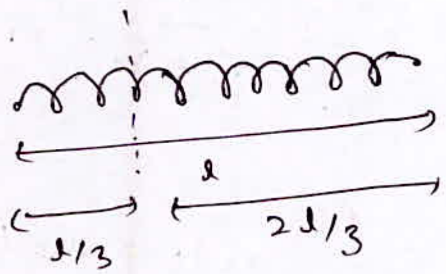
$\boxed{\theta = 45^\circ}$ Ans.

(41)

Ice can not provide larger friction force so one should take small steps. (μ_{ice} is less)

(42)

spring constant k



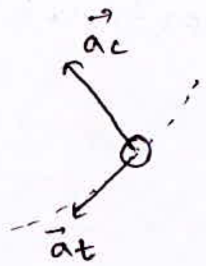
$k \propto \frac{1}{l}$

$kl = \text{const.}$

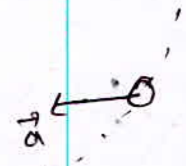
$kl = k' \frac{2}{3} l$

$\boxed{k' = \frac{3}{2} k}$

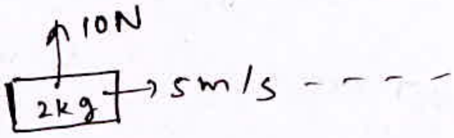
(43.)



Resultant $= \vec{a_c} + \vec{a_t}$

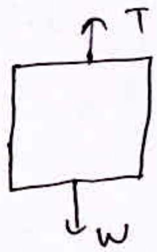


(44)



$F_i = 0 \qquad a = 0$

(45)

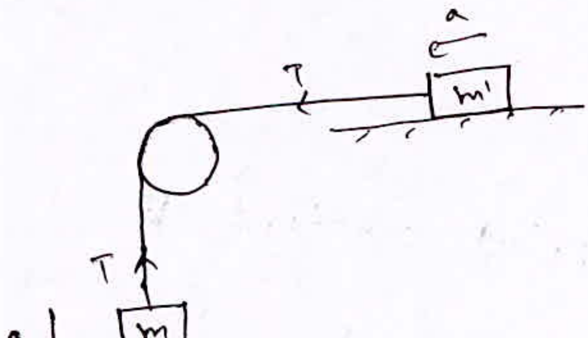


$T - W = \frac{W}{g} a \qquad$ given $T = W$

$a = 0 \Rightarrow \frac{dV}{dt} = 0$

$\boxed{V = \text{constant}}$

(46)

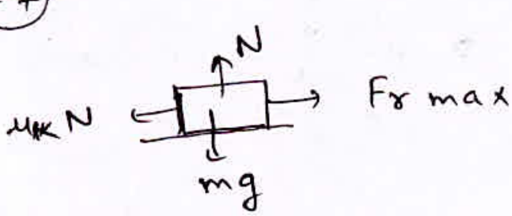


$mg - T = ma \quad -(1)$

$T = m'a \quad -(2)$

$$\boxed{a = \frac{mg}{m + m'}}$$ Ans.

(47)

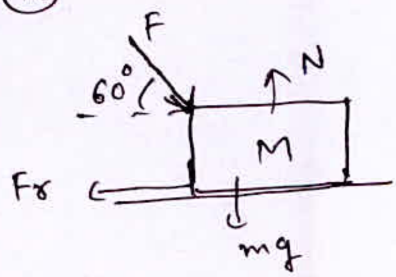


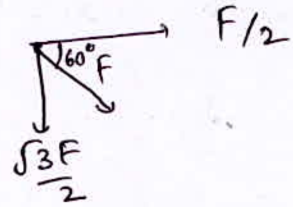
$Fr_{max} = \mu_s N = \mu_s (mg)$

$Fr_{max} - \mu_K mg = ma$

$\boxed{a = (\mu_s - \mu_K) g = 0.98\, m/s^2}$

(48)





$$N = mg + \frac{\sqrt{3}F}{2}$$

$$\frac{F}{2} = \mu\left(mg + \frac{\sqrt{3}}{2}F\right)$$

$$\frac{F}{\cancel{2}} = \frac{1}{\cancel{2}\cancel{\sqrt{3}}}\left(\cancel{\sqrt{3}} \times 10 + \frac{\cancel{\sqrt{3}}}{2}F\right)$$

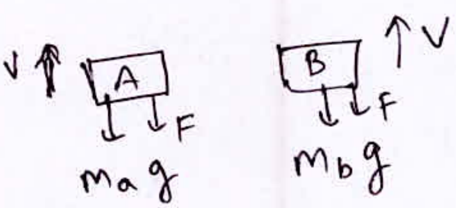
$$\frac{F}{2} = 10 \Rightarrow \boxed{F = 20\ N} \quad \text{Ans.}$$

(49)

$$\vec{F} = \frac{d\vec{P}}{dt}$$

(50)

$$a_A = \frac{M_a g + F}{M_a} = g + \frac{F}{M_a}$$



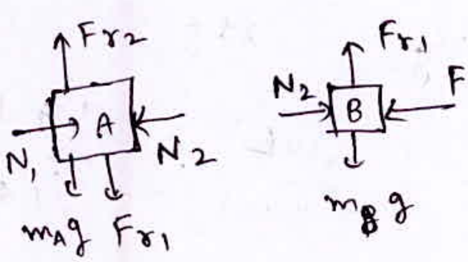
$$a_B = \frac{M_b g + F}{M_b} = g + \frac{F}{M_b}$$

$$\cancel{a_A \ngtr a_B} \quad M_a > M_b$$

$$a_A < a_B \qquad S_A = \frac{v^2}{2a_A}$$

$$S_A > S_B$$

(51)



$$N_1 = N_2 = F$$

$$0 \le Fr_1 \le \cancel{m_B g}\ \mu N_2$$

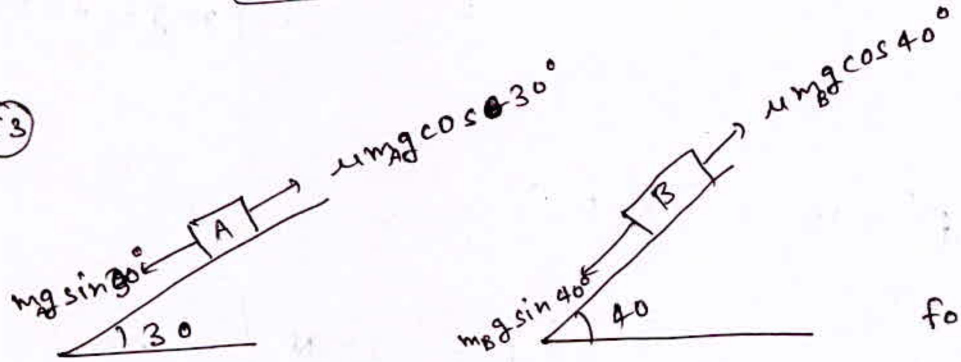
on A Fr_1 will be downwards.

(52)

surfaces are smooth $\mu = 0$

$\boxed{F_{r_1} = 0}$ Ans.

(53)



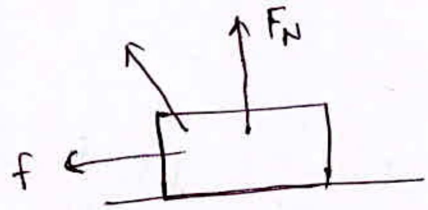
$m_A \sin 30° = \mu_1 m_A g \cos 30°$

$\tan 30° = \mu_1$

for $\tan 40° = \mu_2$

it doesn't depend on m_A or m_B

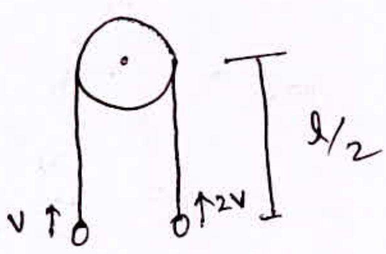
(54)



$f = \sqrt{F_N^2 + f^2}$

$F_N - f < f < F_N + f$

(55)

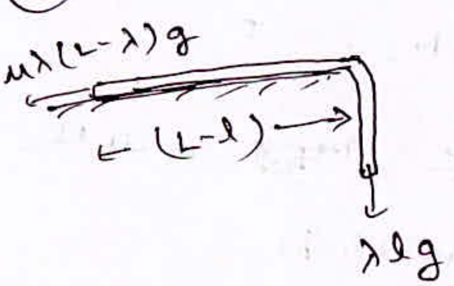


v and 2v are given with respect to rope.

time for monkey 1 $= \dfrac{l}{2v}$

time for monkey 2 $= \dfrac{l}{4V}$

(56)

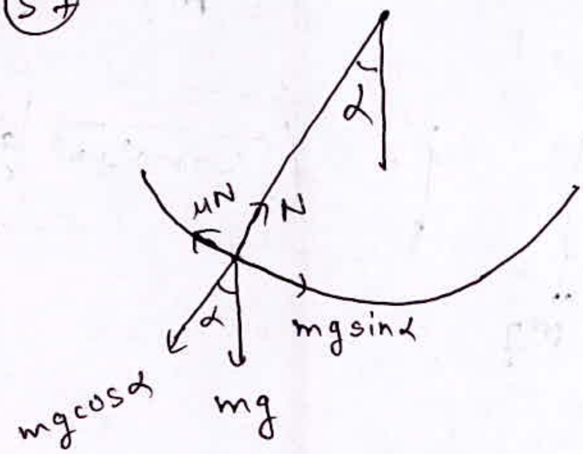


$\mu \lambda (L - l) g = \lambda l g$

$l = \dfrac{\mu L}{(1+\mu)} = \dfrac{1/4\, L}{5/4} = \dfrac{L}{5}$

$l = \dfrac{L}{5} \Rightarrow 20\%$

(57)



$N = mg\cos\alpha$

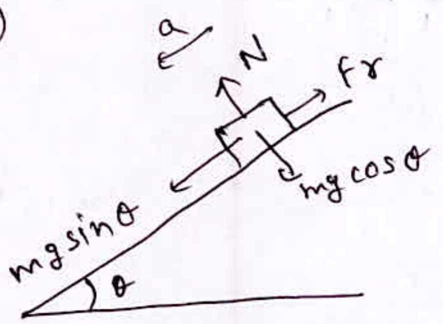
$\mu N = mg\sin\alpha$

$\mu = \tan\alpha$

$\frac{1}{3} = \tan\alpha$

$\boxed{\cot\alpha = 3}$ Ans.

(58)



with friction

$f_r = \mu_k mg\cos\theta$

$a_f = g(\sin\theta - \mu_K\cos\theta)$

without friction

$a = g\sin\theta$

$s = \frac{1}{2} a_f (nt)^2 \quad -(1)$

$s = \frac{1}{2} a\, t^2$

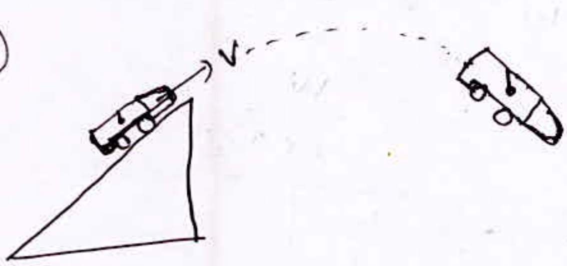
$a_f n^2 = a$

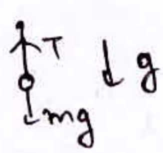
$(\sin\theta - \mu_K \cos\theta)\, n^2 = \sin\theta \qquad \theta = 45^0$

$(1 - \mu_K)\, n^2 = 1$

$\boxed{\mu_K = \left(1 - \frac{1}{n^2}\right)}$ Ans.

(59)

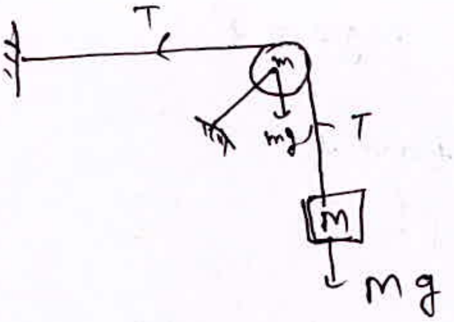


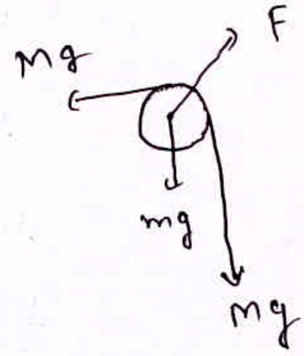


$T - mg = mg$

$\boxed{T = 0}$ Ans.

(60)

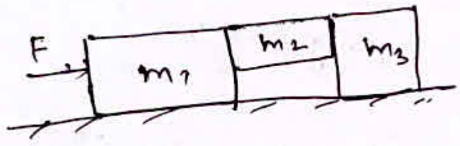


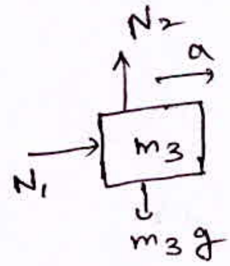


$$T = Mg$$

$$\boxed{F = \left(\sqrt{(m+M)^2 + M^2}\right) g}$$

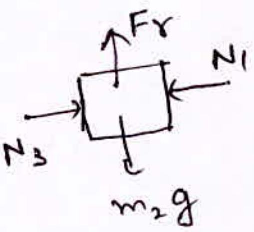
(61)





$$N_1 = m_3 a$$

$$F = (m_1 + m_2 + m_3)\, a \Rightarrow a = \frac{F}{m_1 + m_2 + m_3}$$



$$Fr = \mu N_1 \quad \cancel{mg}$$

$$= \mu\, m_3 \left(\frac{F}{m_1 + m_2 + m_3}\right)$$

$$Fr \geq m_2 g$$

$$\mu\, m_3 \left(\frac{F}{m_1 + m_2 + m_3}\right) \geq m_2 g$$

$$\boxed{F \geq (m_1 + m_2 + m_3)\,\frac{m_2 g}{\mu m_3}}$$

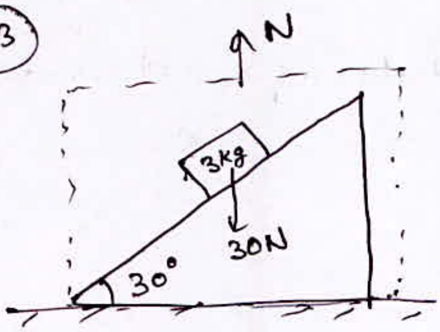
(62)

$$W = 2T\cos\theta$$

$$T = \frac{W}{2\cos\theta}$$

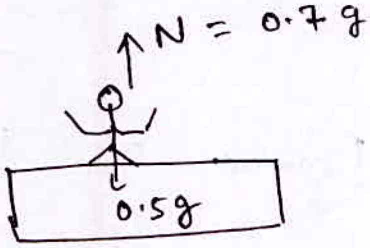
$$\boxed{T \geq \frac{W}{2}}$$

(63)



$N = 30\,N$

(64)



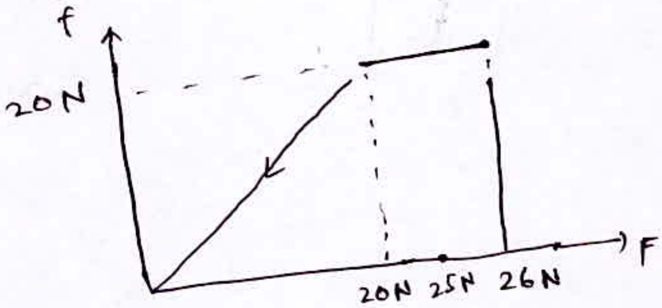
$N - mg = ma$

$(0.7 - 0.5)\,9.8 = 0.5\,a$

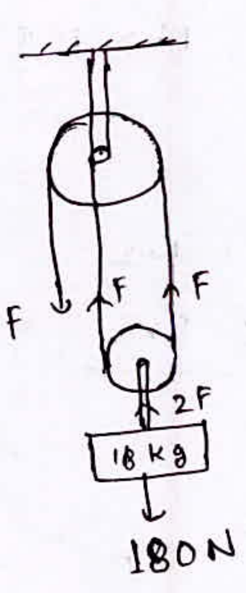
$a = \frac{2}{5} \times 9.8$

$$\boxed{a = 3.92\ m/s^2}$$

(65)



(66)



$2F = 180\ N$

$\boxed{F = 90\,N}$ Ans.

(67)

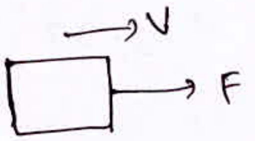
unabl to change by itself the state of rest and of uniform linear motion.

(68) (b)

(69) $-F_{ice} = F_{man}$

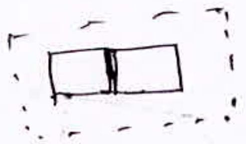
(70) action - reaction $\quad F_{cannon} = -F_{bullet}$

(71)



Second Law $\quad F = \frac{d\vec{p}}{dt}$

if $F = 0 \Rightarrow$ V. constant $\quad$ Ist Law

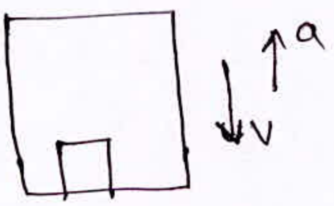


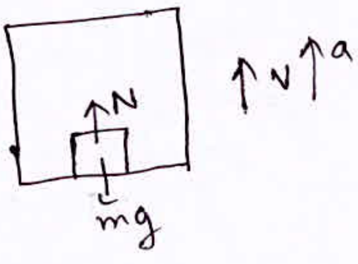
$F_{ext} = 0 \quad d(m_{total}\vec{V}) = 0$

Internal Forces should be equal

action - reaction $\rightarrow$ IIIrd Law

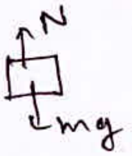
(72)





$N - mg = \underset{+ve}{ma}$

$N > mg$

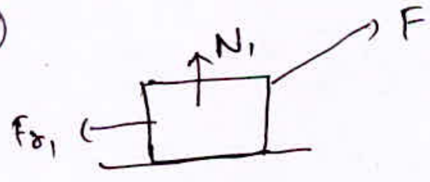


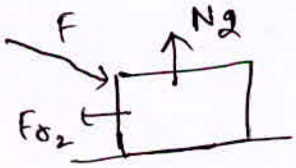
$N - mg = ma$

$N > mg$

$N_1 < N_2$

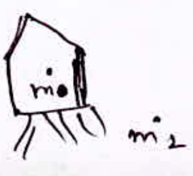
(73)





$\boxed{Fr_1 < Fr_2}$

(74)



$F_{ext} = 0 = \frac{d\vec{p}}{dt} = 0$

Level - 02

Q 1.

O → a_1

from S_1 frame particle is at rest ⇒ velocity zero, and both have same accelaration or zero accelaration.

$S_1 \rightarrow a_1$

O →v, →a_1

from S_2 frame particle is moving with constant ⇒ both have same accelaration or both have zero accelaration.

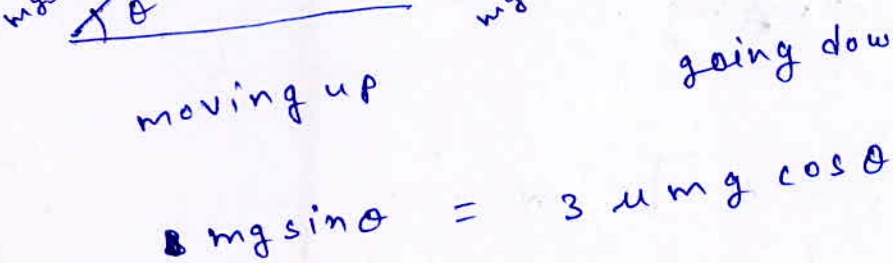
$S_2 \rightarrow a_1$

hence → if particle has zero accelaration ⇒ S_1 & S_2 both have zero accelaration.

→ if particle has a_1 accelaration ⇒ S_1 & S_2 both have a_1 accelaration.

Ans. (4)

Q 2.



moving up

going down

$F_1 = mg\sin\theta + \mu mg\cos\theta$

$F_2 = -\mu mg\cos\theta + mg\sin\theta$

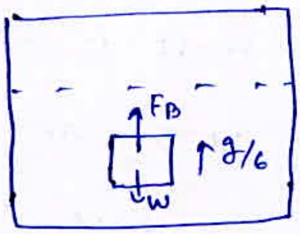
$F_1 = 2F_2$

$mg\sin\theta = 3\mu mg\cos\theta$

$\tan\theta = 3\mu$

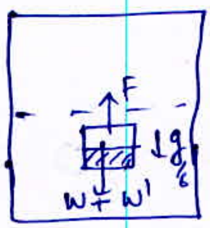
$\boxed{\theta = \tan^{-1} 3\mu}$ Ans.

(3)



$$F_B - W = \frac{W}{g}\times g/6 \quad -(1)$$

$$W + W' - F_B = \left(\frac{W+W'}{g}\right)\frac{g}{6} \quad -(2)$$



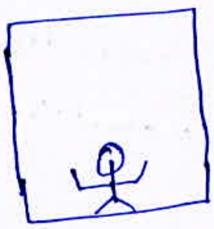
(1) + (2)

$$W' = \frac{2W + W'}{6}$$

$$W' = \frac{2}{5}W$$

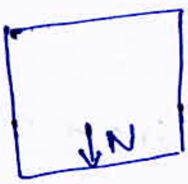
$$\boxed{M' = \frac{2}{5}\times 5 = 2\,kg}$$

(4)



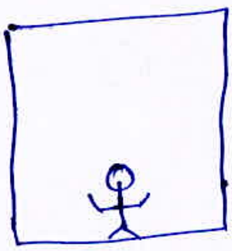
$$mg - N = ma$$

$$N = mg - ma$$



$$\boxed{N = mg - ma}$$ Ans.

(5)



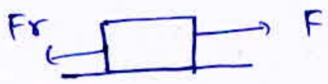
$$\Rightarrow N - mg = ma$$

$$\boxed{N = m(g+a)}$$ Ans.

(6)

$$\boxed{\mu_r < \mu_k < \mu_s}$$ Ans.

(7)



$$v = u + at$$
$$4 = 0 + a\times 2 \Rightarrow a = 2\,m/s^2$$

$$F - \mu mg = ma$$

$$\mu = \frac{200 - 60}{300} = 0.47$$ Ans.

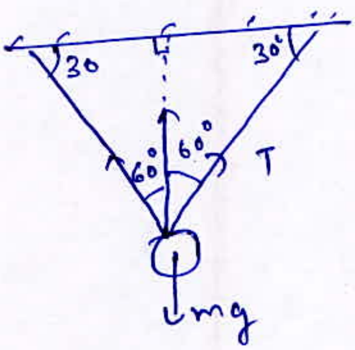
(8)

$v = u + at$ $\Rightarrow$ $a = -3\ m/s^2$

$-12 = 10 + a \cdot 4$

$\boxed{F = ma = -30\,N}$ Ans.

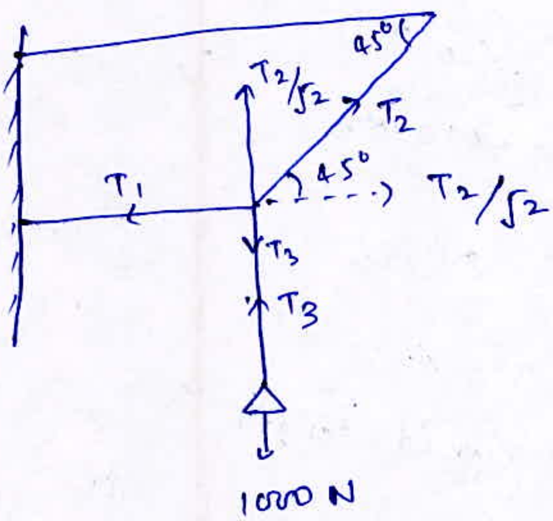
(9)



$2T\cos 60^\circ = mg$

$\boxed{T = \frac{20}{2 \times \frac{1}{2}} = 20\,N}$ Ans.

(10)



$T_3 = 1000\,N$

$T_3 = T_2/\sqrt{2}$

$T_2 = 1000\sqrt{2}$

$\frac{T_2}{\sqrt{2}} = T_1$

$\boxed{T_1 = 1000\,N}$

(11)

$\frac{1}{2}kx^2 = mgh$

$\frac{\frac{1}{2}kx_1^2}{\frac{1}{2}kx_2^2} = \frac{mgh_1}{mgh_2}$ $\Rightarrow$ $\frac{h_2}{h_1} = \frac{x_2^2}{x_1^2}$

$h_2 = h_1 \times \frac{x_2^2}{x_1^2} = 2 \times \frac{6^2}{4^2} = 4.5\,m$

(12)

$$F_{avg} = (mv_f - mv_i)/\Delta T$$
$$= 0.5(15-(-10))/1/50$$
$$= \frac{0.5 \times 25}{1/50}$$

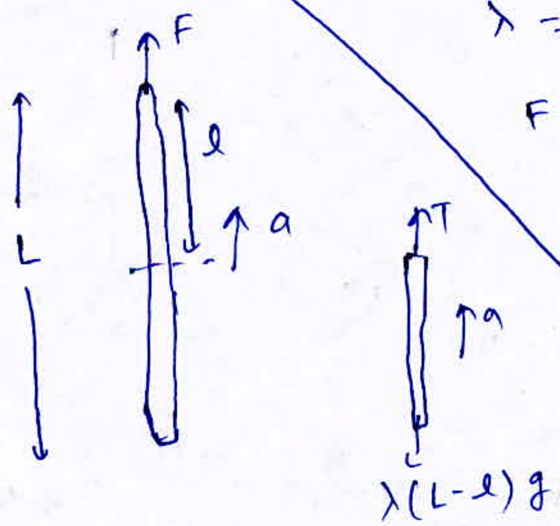
$F_{avg.} = 5 \times 5 \times 25 = 625\,N$ Ans.

(13)

$$v^2 = u^2 + 2as$$
$$0 = (30)^2 + 2a \times (4\times10^{-3})$$
$$a = \frac{-(30)^2}{2\times 4\times10^{-3}} \; km/hr^2$$
$$0 = (60)^2 + 2\left(\frac{-(30)^2}{2\times4\times10^{-3}}\right) s_2$$

$\boxed{s_2 = 16\ m}$ Ans.

(14)



λ = mass per unit length

$F - \lambda Lg = \lambda La$ — ①

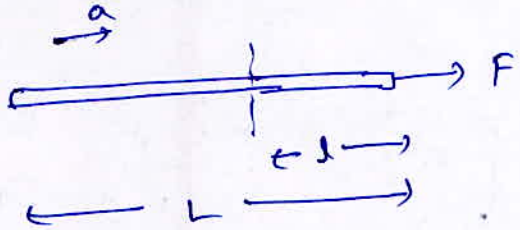
$T - \lambda(L-l)g = \lambda(L-l)a$ — ②

② — ①

$T - F = -\lambda la - \lambda lg$

(14)

~~Fe~~ λ = mass per unit length.



$F = \lambda L a$

$F - T = \lambda l a$

$\lambda L a - T = \lambda l a$

$T = \lambda (L - l) a$

$a = F / \lambda L$

$$\boxed{T = \frac{F(L-l)}{L}}$$

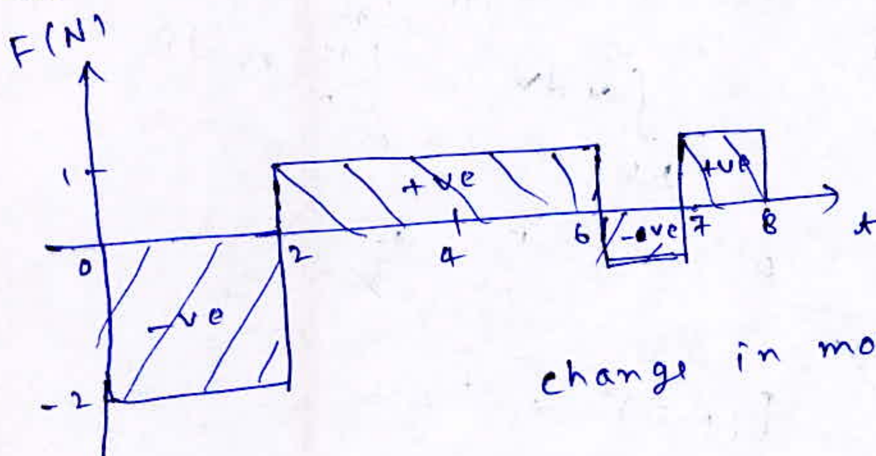
(15)

$F = \frac{d\vec{p}}{dt}$ = change in momentum per second

$= 50 \times 10^{-3} \times \frac{\cancel{30}}{\cancel{60}_{2}} \times \cancel{400}^{200}$

$$\boxed{F = 10\text{ N}}$$

(16)

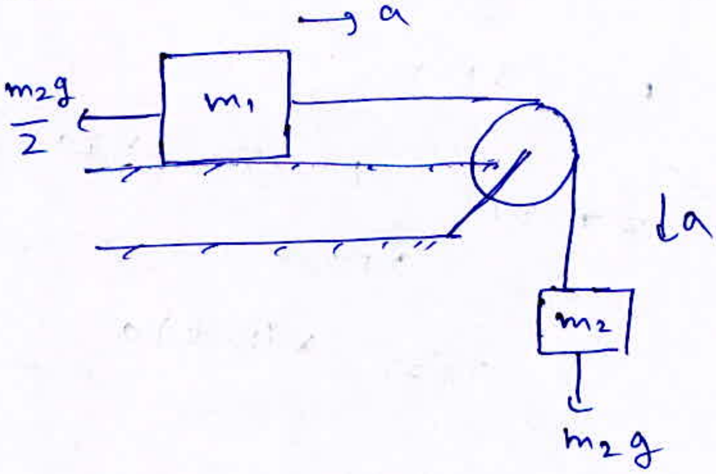


F - t graph area gives change in momentum

change in momentum $= -2\times2 + 4\times1 - 1\times1 + 1\times1$

$= 0$

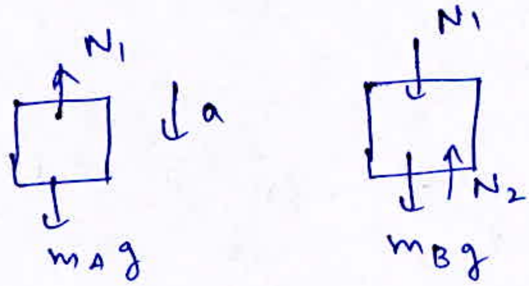
(17)



$$m_2 g - \frac{m_2 g}{2} = (m_1 + m_2)a$$

$$\boxed{a = \frac{m_2 g}{2(m_1 + m_2)}}$$

(18)

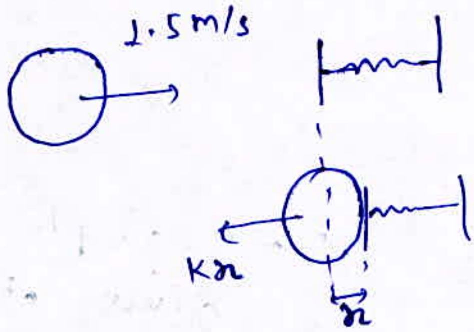


$$m_A g - N_1 = m_A a$$

$$5 - N_1 = 0.5 \times 2$$

$$\boxed{N_1 = 4\ N}$$ Ans.

(19)



$$F = kx$$

$$a = \frac{kx}{m}$$

$$v\frac{dv}{dx} = \frac{kx}{m}$$

$$\int_{1.5}^{0} v\,dv = \int_{0}^{x} \frac{k}{m}\, x\,dx$$

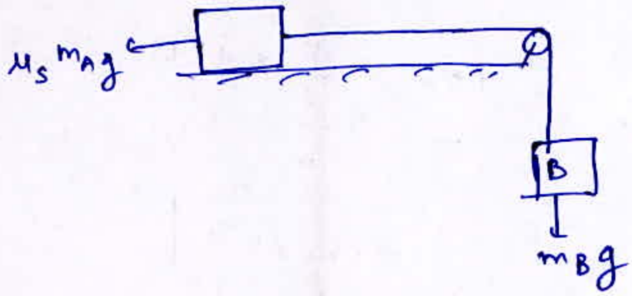
$$\frac{(1.5)^2 - 0}{\cancel{2}} = \frac{k}{m}\,\frac{x^2}{\cancel{2}}$$

$$x = \sqrt{\frac{(1.5)^2 \times 0.5}{50}}$$

$$= 1.5 \times 10^{-1}$$

$$\boxed{x = 0.15\,m}$$

(20)



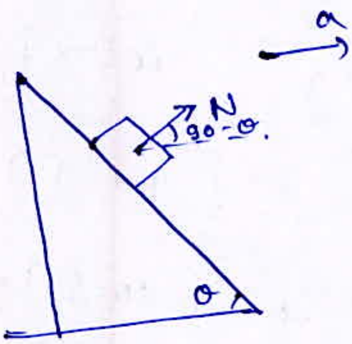
$$\mu_s m_A g = m_B g$$

$$m_B = \mu_s m_A$$

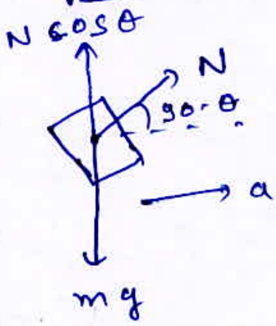
$$= 0.2 \times 2$$

$$\boxed{m_B = 0.4\ kg}$$

(21)



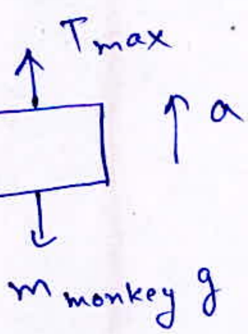
$\cancel{N \sin\theta = ma}$



$$N\cos\theta = mg$$

$$\boxed{N = \frac{mg}{\cos\theta}}$$

(22)

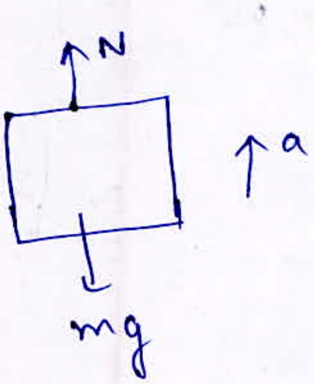


$$T_{max} - mg = ma$$

$$250 - 200 = 20\ a$$

$$\boxed{a = 2.5\ m/s^2}$$

(23)

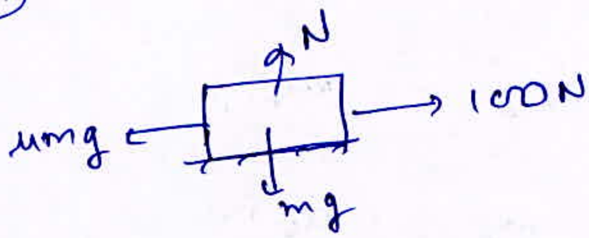


$$N - mg = ma$$

$$N - 800 = 400$$

$$\boxed{N = 1200N}$$

(24)

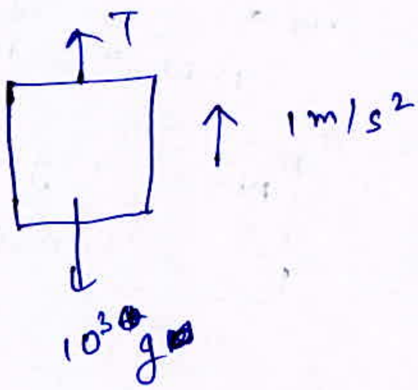


$$100 - \mu mg = ma$$

$$a = \frac{100 - \frac{1}{2}\times 100}{10}$$

$$\boxed{a = 5\ m/s^2}$$

(25)



$$T - 10^3 g = 10^3 \times 1$$

$$T = 10^3 (1 + g)$$

$$= 10^3 (10.8)$$

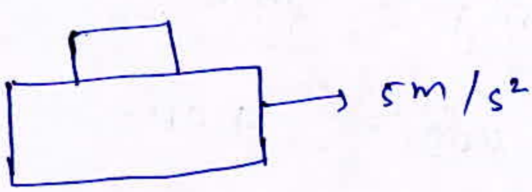
$$\boxed{T = 10800\ N}$$

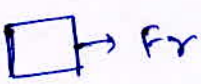
(26)

$$F = \frac{d\vec{p}}{dt} = \frac{\Delta(mv)}{\Delta t} = \frac{150\times 10^{-3}\times(20-0)}{0.1}$$

$$\boxed{F = 30\ N}$$

(27)





$$Fr = ma$$

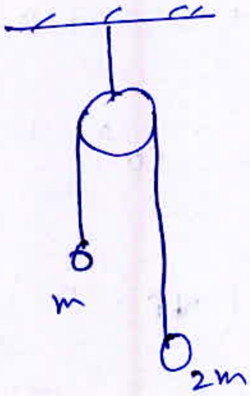
$$= 1\times 5$$

$$\boxed{Fr = 5\ N}$$

(28)

$$\eta = \frac{750 \times 3}{250 \times 12} = \frac{3}{4} = 75\%$$

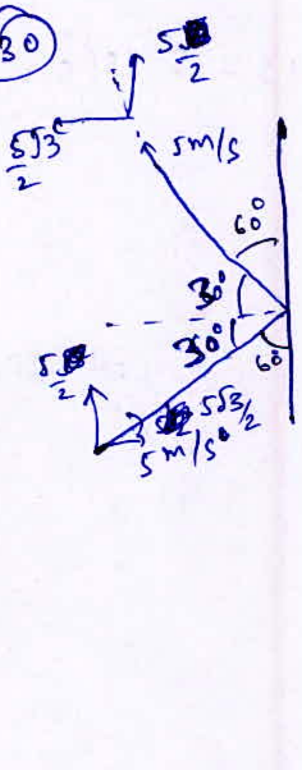
(29)



$$2mg - mg = 3ma$$

$$\boxed{a = g/3}$$ Ans.

(30)



$F_{ball} = -F_{wall}$

change in momentum of ball $= -F_{wall} \times \Delta t$

$$\frac{m\left(-\frac{5}{2}\hat{j} + \frac{5\sqrt{3}}{2}\hat{i} + \frac{5}{2}\hat{j} + \frac{5\sqrt{3}}{2}\hat{j}\right)}{0.2} = -F_{wall}$$

$$F_{wall} = \frac{3 \times 5\sqrt{3}}{0.2}$$

$$= 15\sqrt{3} \times 5$$

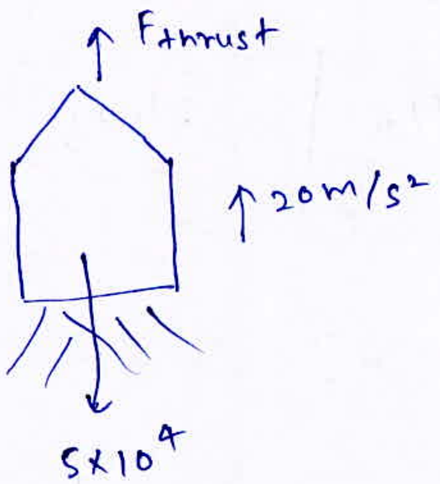
$$= 75\sqrt{3}$$

(31)

$$F = \frac{d\,m\vec{v}}{dt} = \dot{m}(300 - 0) = 210$$

$$\boxed{\dot{m} = \frac{210}{300} = 0.7 \text{ kg/s}}$$

(32)



$$F_{thrust} - 5\times10^4 = 5\times10^3 \times 20$$

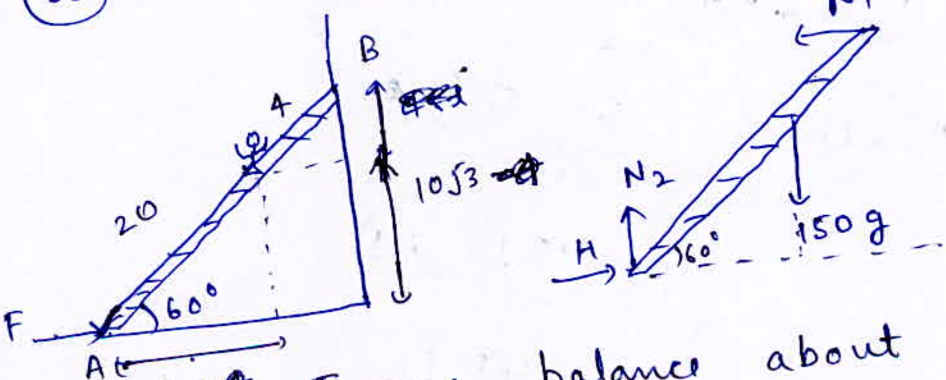
$$F_{thrust} = 15\times10^4$$

$$F_{thrust} = \dot{m}(v_f - 0)$$

$$15\times10^4 = \dot{m}(800 - 0)$$

$$\boxed{\dot{m} = \frac{15}{8}\times10^2 = 187.5 \text{ kg/s}}$$

(33)



$N_2 = 150 \times 32$

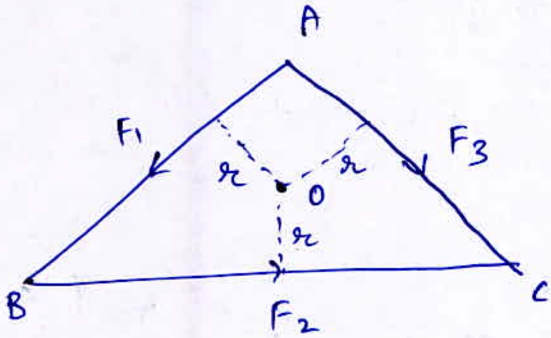
$F = N_1$

Torque balance about point A

$$15\cancel{0} \times 32 \times \left(\cancel{10 - 4}\ \frac{8}{\sqrt{3}}\right) = 1\cancel{0}\sqrt{3} \times N_1$$

$$N_1 = 15 \times 32 \left(\cancel{\frac{10}{\sqrt{3}} - \frac{4}{3}}\right) \times \frac{8}{\sqrt{3}}$$

(34)



torque of F_1 & F_2 is anticlockwise direction and has magnitude

$$(F_1 r + F_2 r) = F_3 r$$

$$\boxed{F_3 = F_1 + F_2}$$

(35)

$$F = 600 - 2\times10^5 t$$

$$F = 0$$

$$600 = 2\times10^5 t$$

$$t = 3\times10^{-3} \text{ sec.}$$

$$\text{Impulse} = \int_0^{3\times10^{-3}} F\,dt$$

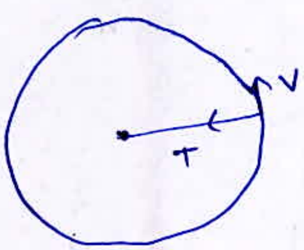
$$= \int_0^{3\times10^{-3}} (600 - 2\times10^5 t)\,dt$$

$$= \left[600t - 10^5 t^2\right]_0^{3\times10^{-3}}$$

$$= (600 - 10^5 \times 3\times10^{-3})\, 3\times10^{-3}$$

$$= .9 \text{ N-s}$$

(36)



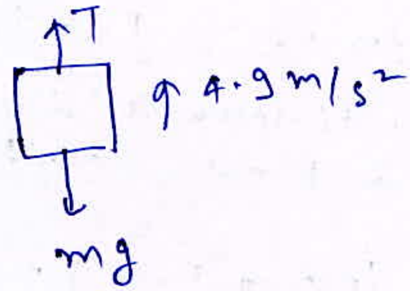
$$T = \frac{mv^2}{l}$$

$$25 = \frac{0.25 \times v^2}{1.96}$$

$$196 = v^2$$

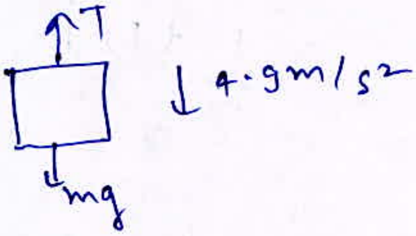
$$\boxed{v = 14 \text{ m/s}}$$

(37)



$$T - mg = m(4.9)$$

$$T_1 = 9.8m + 4.9m$$



$$mg - T_2 = m(4.9)$$

$$T_2 = 9.8m - 4.9m$$

$$\boxed{\frac{T_1}{T_2} = 3}$$

(38)

$$v = u + at$$

$$30 = 0 + \frac{6}{1}t$$

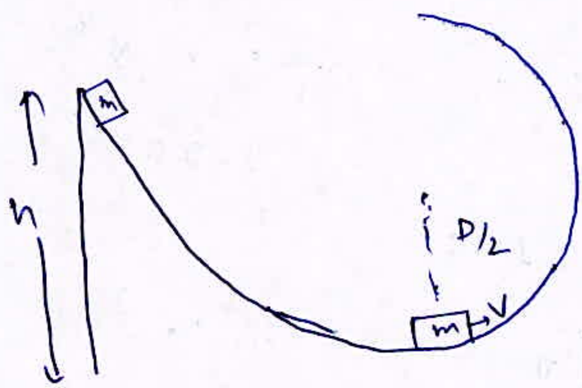
$$\boxed{t = 5\ \text{sec}}$$

(39)

$$\vec{F}.dt = d(m\vec{v})$$

Impulse = change in linear momentum

(40)



$$v = \sqrt{2gh} = \sqrt{5gD/2}$$

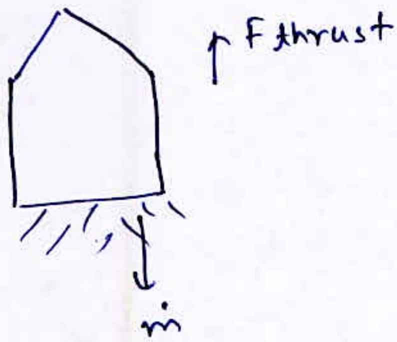
$$\boxed{h = \frac{5}{4}D}$$ Ans.

(41)

$$\mu \cancel{m} g = \cancel{m} \frac{v^2}{R}$$

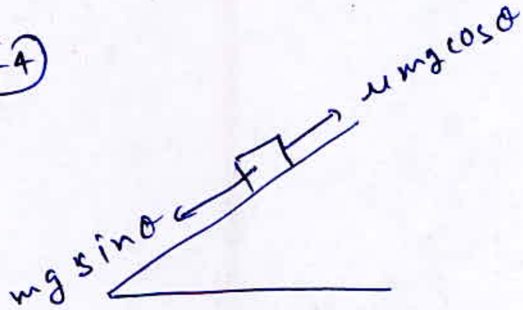
$$\mu = \frac{(4.9)^2}{4 \times 9.8} = \frac{4.9}{8} = 0.61 \quad \text{Ans.}$$

(42)



(43) First Law

(44)



$$mg \sin\theta = \mu mg \cos\theta$$

$$\tan\theta = \mu$$

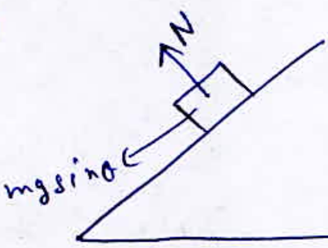
$$\boxed{\theta = \tan^{-1}\mu} \quad \text{Ans.}$$

(45)

Definition

(46) viscous force

(47)



$$N = mg\cos\theta$$

(48) $\boxed{\tan\theta = \mu = \frac{3}{4}}$ → ref. Q (44)

(49)

$$F = \Delta(mv) = mnv$$

(50)

$$a = \frac{F}{m} = \frac{F}{W/g} = \frac{5}{9.8/9.8} = 5\ m/s^2$$

(51)

$$\boxed{F_{ext} = 0}$$

$$mv = \frac{m}{4} \times 0 + \frac{3m}{4} v'$$

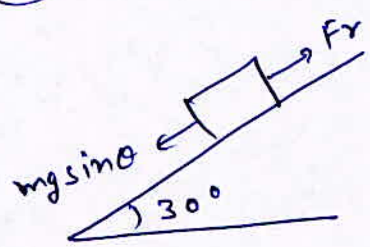
$$v' = \frac{4v}{3}$$

(52)

$$p = a + bt + ct^2$$

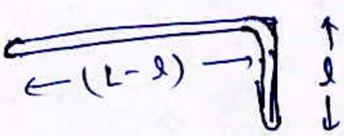
$$F = \frac{d\vec{p}}{dt} = b + 2ct$$

(53)



$$Fr = mg\sin\theta$$
$$= 2 \times g \times \sin 30^\circ$$
$$= g$$
$$= 9.8\ N$$

(54)



$$\mu \frac{m}{L}(L-l)g = \frac{m}{L} l g$$

$$l = \frac{\mu L}{1+\mu} = \frac{\frac{1}{4}}{5/4} L$$

$$l = \frac{L}{5} \Rightarrow 20\%$$ Ans.

(55)

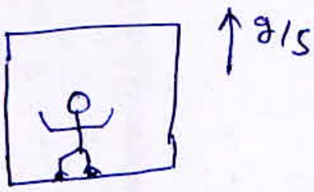
$0 \le F_r \le \mu_s mg$

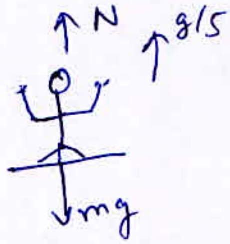
$0 \le F_r \le 0.5 \times 20$

$0 \le F_r \le 10$

$F_r < 10 \Rightarrow \boxed{F_r = F = 2.5\ N}$

(56)



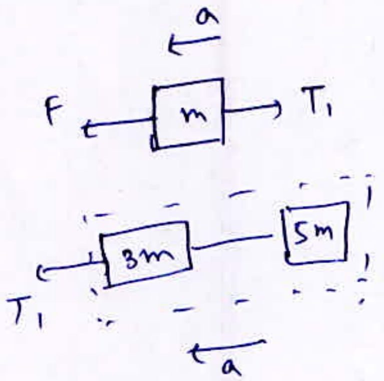


$N - mg = m\,g/5$

$N = 6mg/5$

$\boxed{N = 720\ N}$ Ans.

(57)

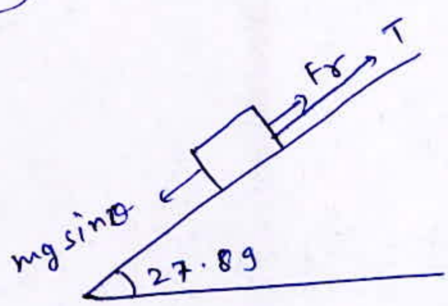


$F - T_1 = ma$

$T_1 = 8ma$

$\boxed{a = \dfrac{16}{8m} = \dfrac{2}{m}}$ Ans.

(58)



$mg\sin\theta - F_r = T$

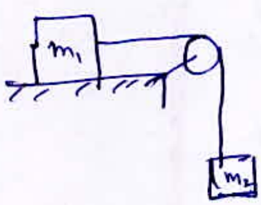
$0 \le F_r \le \mu mg\cos(27.89)$

$0 \le F_r \le 0.8\,mg\,(27.89)$

$F_{r\,max} \geq mg\sin(27.89^\circ)$

$\boxed{T = 0}$ Ans.

(59)



$m_2 g = (m_1 + m_2)a$

$\boxed{a = \dfrac{m_2 g}{m_1 + m_2}}$ Ans.

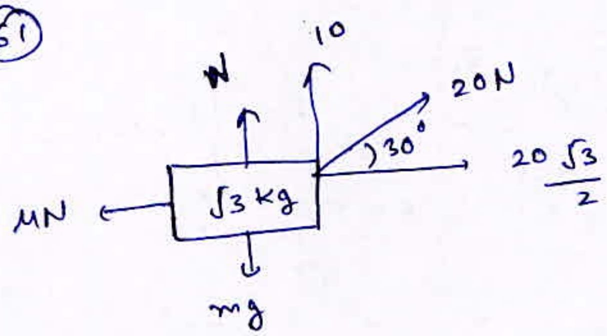
(60)

$$mg = \frac{\Delta(mv)}{\Delta t} \qquad \Delta t = 1 \text{ sec.}$$

$$10\times\cancel{10^{-3}}\times g = 10(.5\times\cancel{10^{-3}}\times 2v)$$

$$\boxed{v = \frac{g}{10}\ \text{m/s} = 98\ \text{cm/s}}$$

(61)



$$N = (\sqrt{3}-1)\,10$$

$$\mu N = 0$$

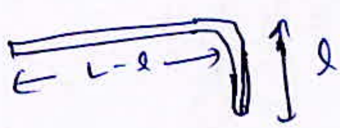
$$\boxed{a = \frac{\frac{20\sqrt{3}}{2}}{\sqrt{3}} = 10\ \text{m/s}^2}$$

(62)

$$238\times 0 = 234\times V' + 4V$$

$$V' = -\frac{4}{234}V$$

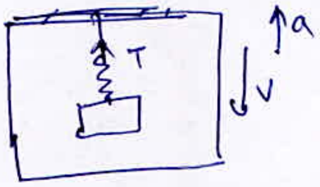
(63)



$$\frac{m}{L}\,l\,g = \frac{\mu m(L-l)}{L}\,g$$

$$\mu = \frac{l}{L-l}$$

(64)



$$T - mg = ma$$

$$T = mg + ma$$

$$T < mg \Rightarrow a \; -ve$$

$a \rightarrow$ downwards $\qquad v \rightarrow$ increase

$$T > mg \Rightarrow a \; +ve$$

$a \rightarrow$ upwards $\Rightarrow v \rightarrow$ decreasing

(65)

$$\cancel{(2p\hat{i}) + (p\hat{j})} +$$

$$2p\hat{i} + p\hat{j} + p' = 0$$

$$p' = -2p\hat{i} - p\hat{j}$$

$$\boxed{|p'| = \sqrt{5}\,p}$$ Ans.

Assertion & Reason

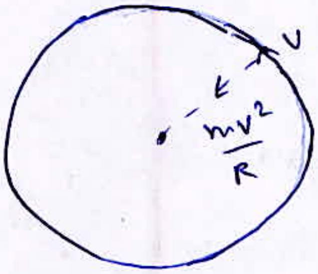
(1) Newton's II^{nd} law

(2) $\Sigma \vec{F}_{ext} = m\vec{a}$ if $\Sigma \vec{F}_{ex} = 0 \Rightarrow \vec{a} = 0$

Reason is False

(3) $\vec{F} = \dfrac{d\vec{p}}{dt}$

(4) $\vec{a_c} = \dfrac{mv^2}{R}$



uniform motion $\vec{v}$ constant

(5) $\vec{p} = m\vec{v}$ momentum is not same.

For all bodies

(7) Impulse $= F\,dt = d\vec{p}$ Same dimension

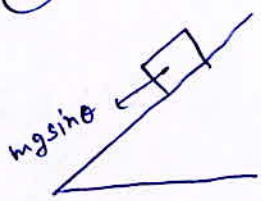
(8) $F = ma$

for same acceleration for greater mass we need greater Force

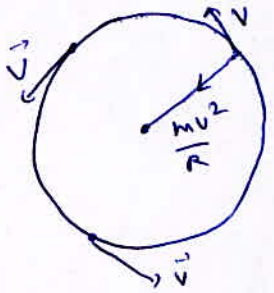
(9) $\dfrac{d\vec{p}}{dt} = \vec{F}$

$\vec{a} = \dfrac{d\vec{p}}{dt} / m$

(11)



(12)



$\vec{v}$ is changing

uniform motion $\vec{a} = 0$

(13)

$\vec{F}_{ext} = 0$ momentum conservation.

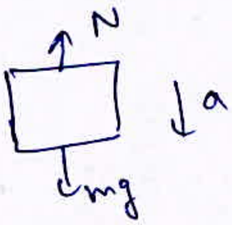
$$K.E_{rifle} = \frac{|\vec{P}|^2}{2M_{rifle}} \qquad K.E._{bullet} = \frac{|\vec{P}|^2}{2M_{bullet}}$$

$$K.E._{bullet} > K.E._{rifle}$$

(14)

$\vec{F}_{ext} = 0$ Momentum will be conserved

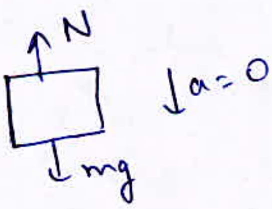
(15)



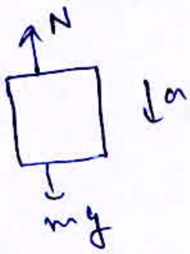
$N = mg - ma$

$N < mg$

(16)



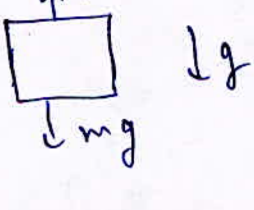
$N = mg$



$N = mg - ma$

$N < mg$

(17)



$N = mg - mg = 0$

(18)

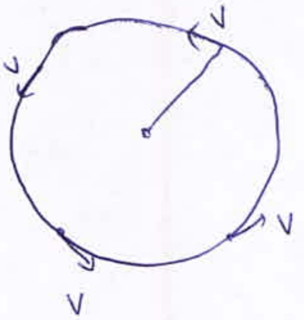
$\vec{F}\,\Delta t = \Delta mv$

F will decrease if Δt increases.

(19)

$\vec{F} = m\vec{a}$

(20)



$|\vec{v}|$ same but direction of velocity vector is changing

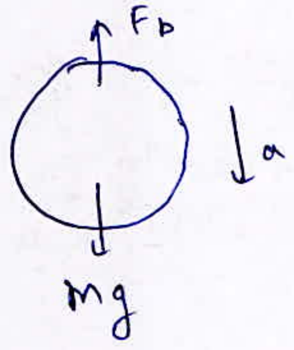
(21)

both are wrong

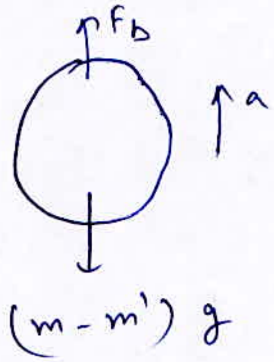
(22)

Previous Year's Questions

(1)



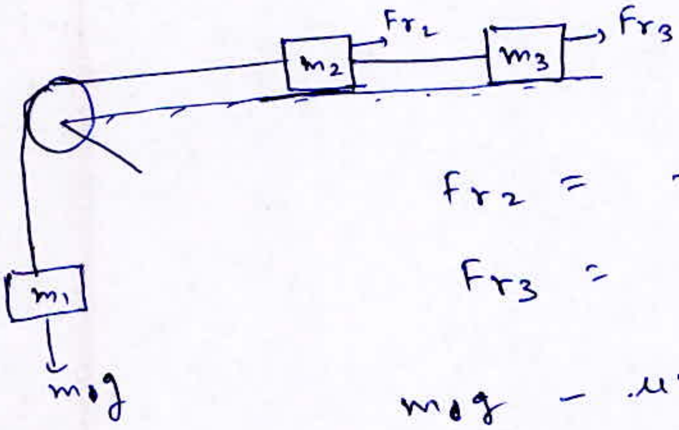
$$mg - F_b = ma$$



$$F_b - (m-m')g = (m-m')a$$

$$\boxed{m' = \frac{2ma}{g+a}}$$

(2)



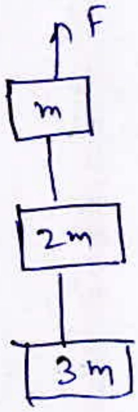
$$Fr_2 = \mu mg$$

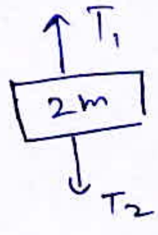
$$Fr_3 = \mu mg$$

$$m_1 g - \mu mg - \mu mg = 3m\,a$$

$$\boxed{a = \frac{g(1-2\mu)}{3}}$$

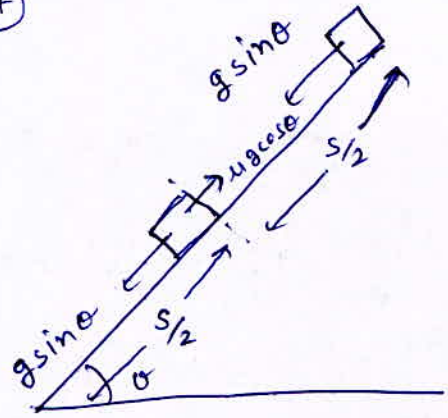
(3)





$$\boxed{F_{net} = 2ma = 0}$$

(4)

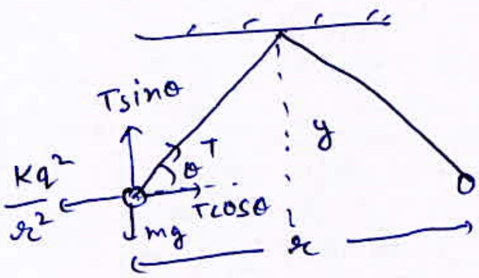


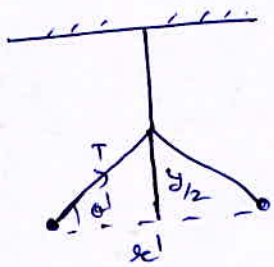
$$(\mu g\cos\theta - g\sin\theta) = g\sin\theta$$

$$\mu g\cos\theta = 2g\sin\theta$$

$$\boxed{\mu = 2\tan\theta}$$

(5)





$$T\sin\theta = mg$$

$$T\cos\theta = \frac{Kq^2}{r^2}$$

$$\tan\theta = \frac{mgr^2}{Kq^2}$$

$$\frac{Kq^2}{mg} = \frac{r^2}{y/r/2}$$

$$T'\sin\theta' = mg$$

$$T'\cos\theta' = \frac{Kq^2}{r'^2}$$

$$\tan\theta' = \frac{mgr'^2}{Kq^2}$$

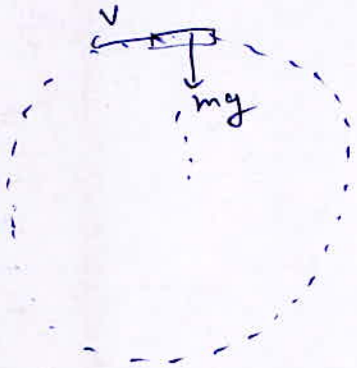
$$\frac{Kq^2}{mg} = \frac{r'^2}{y/2/r'/2}$$

$$\frac{r^3}{2y} = \frac{r'^3}{y}$$

$$\boxed{r' = \left(\frac{r^3}{2}\right)^{1/3} = \frac{r}{\sqrt[3]{2}}}$$

Laws of Motion

(1)



$$mg = \frac{mv^2}{r}$$

$$v = \sqrt{rg}$$

(3)

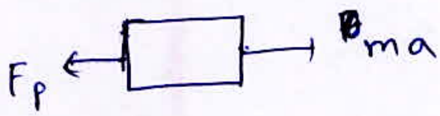
$$v^2 = u^2 + 2as$$

$$0 = (50)^2 + 2a(6 \times 10^{-3})$$

$$0 = (100)^2 + 2a\,s$$

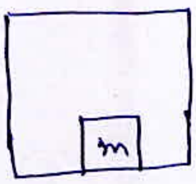
$$s = \frac{(100)^2}{2 \times \left(\frac{(50)^2}{2 \times 6 \times 10^{-3}}\right)} = 24 \text{ m.}$$

(4)



$$F = ma - F_p$$

(5)



$$N = mg + ma$$ going up

$$= 720$$

$$N = mg - ma$$ going down

$$= 480$$

(6)

$$x = 7t + 4t^2 \quad , \quad y = 5t$$

$$v_x = 7 + 8t \qquad v_y = 5$$

$$a_x = 8 \quad , \quad a_y$$

$$\boxed{a = \sqrt{a_x^2 + a_y^2} = 8 \text{ m/s}^2}$$

(7)

$$3 = 2 + \frac{x}{m} \times 2$$

$$\frac{x}{m} = \frac{1}{2}$$

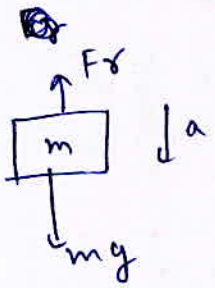
$$\boxed{x = \frac{m}{2} = 0.25\ N}$$

(8)

$$F_r = 500\ N$$

$$\boxed{a = \frac{1000 - 500}{1000} = 0.5\ m/s^2}$$

(9)



$$F_r = m(g - a)$$

(10)

$$\vec{F} = \frac{d\vec{p}}{dt} = \frac{2m \times 10}{\Delta t}$$

$$\vec{a} = \frac{\vec{F}}{m} = \frac{2 \times 10}{\Delta t}$$

(11)

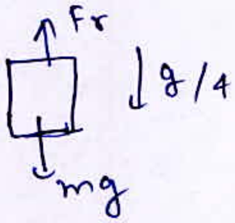
$$N_1 = mg + ma = W_1$$

$$N_2 = mg - ma = W_2$$

$$N = \frac{N_1 + N_2}{2} = \frac{W_1 + W_2}{2}$$

when constant speed $N = mg$

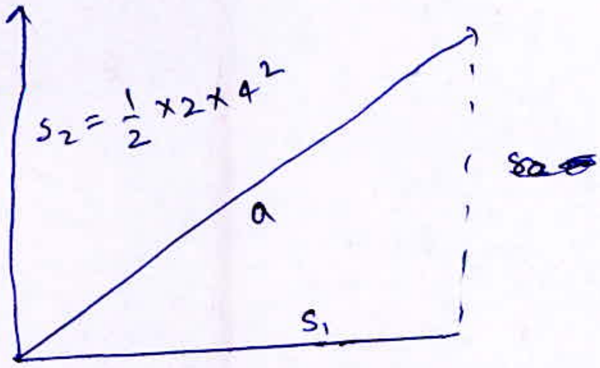
(12)



$$Fr = mg - mg/4$$

$$\boxed{Fr = \frac{3mg}{4} = \frac{3W}{4}}$$

(13)



$3 \times 4 = 12$

$$|\vec{a}| = \sqrt{12^2 + 16^2}$$

$$= 20 \text{ m.}$$

(14)

$$v = u + at$$

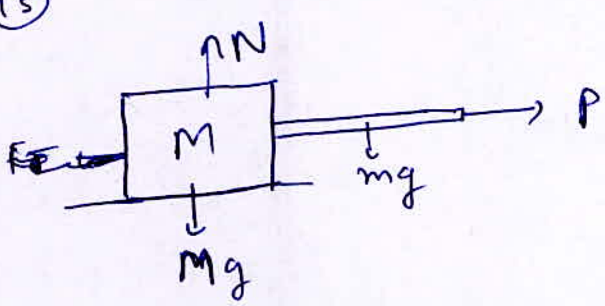
$$-2 = 10 + a \times 4$$

$$a = -3$$

$$F = 10 \times -3$$

$$\boxed{F = -30\text{ N}}$$

(15)



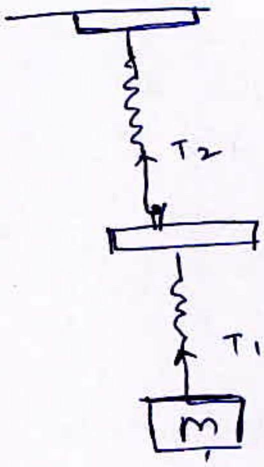
$$N = (M+m)g$$

$$a = \frac{P}{M+m}$$

$$P - T = m \cdot \frac{P}{(M+m)}$$

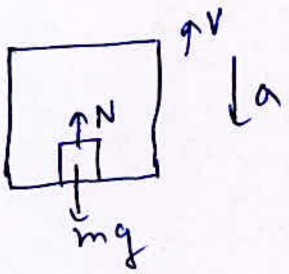
$$T = P\left(1 - \frac{m}{M+m}\right) = \frac{PM}{M+m}$$

(16)



$T_1 = T_2 = mg$

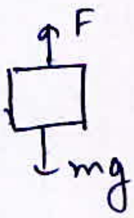
(17)



$N = mg - ma$

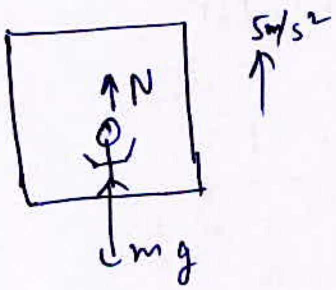
$N < mg$

(18)



$F > mg$

(19)



$N = mg + ma$

$= 1200\ N$

(20)

$a = 0 \Rightarrow F = 0$

(21)

In Spring Balance $W = N = mg + ma$

In Physical Balance Position change

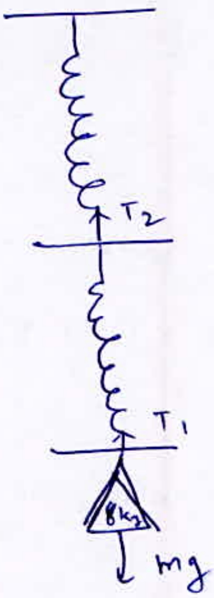
(22)

In case I $\quad a = g$

In case II $\quad$ Relative accelaration $= g + a$

$t_1 > t_2$

(23)



$T_1 = T_2 = mg$

(24)

$a_1 = \frac{F}{3} \qquad a_2 = \frac{F}{5}$

$v = \cancel{u}^{0} + at$

$a_1 t_1 = a_2 t_2$

$\frac{t_1}{t_2} = 3/5$

(25)

$10 = 0 + a \times 0.1$

$a = 100$

$F = ma = 0.1 \times 100 = 10N$

(26)

Uniform straight line motion

(27)

$$T - mg = ma$$

$$T = mg + ma$$

$$T = 6000\,N$$

(28)

Relative velocity in horizontal direction is zero.

(29)

$$v^2 = u^2 + 2as$$

$$0 = (100)^2 + 2a \times 6\times10^{-2}$$

$$a = \frac{-10^4}{2\times6\times10^{-2}}$$

$$|\vec{F}| = |m\vec{a}| = \frac{5\times10^6\times10^{-3}}{12} = 417\,N$$

(30)

$$F = mv = 0.05 \times 400 = 20\,N$$

(31)

$$N = mg - ma$$

(32)

$$|a| = \left|\frac{F}{m}\right| = \frac{Kx}{m} = \frac{15\times20\times10^{-2}}{0.3} = 10\,m/s^2$$

(33)

$N = mg + ma$

(34)

$$\dot{m} = \frac{F}{v} = \frac{210}{300} = 0.7 \text{ kg/s}$$

(35)

$$v^2 = u^2 - 2as$$

$$0 = (250)^2 - 2 \times a \times 12 \times 10^{-2}$$

$$a = \frac{(250)^2}{2 \times 12 \times 10^{-2}}$$

$$F = ma = \frac{20 \times 10^{-3} \times (250)^2}{2 \times 12 \times 10^{-2}} = 5.2 \times 10^3 \text{ N}$$

(36)

$$F \Delta t = \Delta mv$$

$$F = \frac{\Delta mv}{\Delta t} = \frac{150 \times 10^{-3} \times 20}{0.1} = 30 \text{ N}$$

(37)

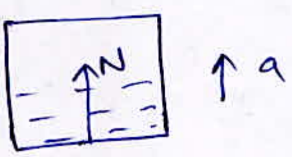
$$N = mg + ma = 1200 \text{ N}$$

(38)

$$T = mg + ma$$

$$\frac{250 - 200}{20} = a = 2.5 \text{ m/s}^2$$

(39)



$N = mg + ma = P_u A$ $\quad P_u > P_o > P_d$

$N = mg = P_o A$ $\quad R_u > R_o > R_d$

$N = mg - ma = P_d A$

(40)

$$F_{thrust} - mg = ma$$

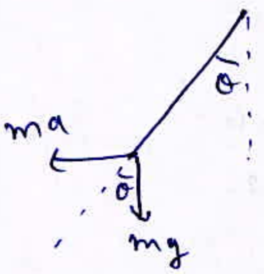
$$F_{thrust} = m(g+a) = 7\times10^5\ N$$

(41)

$$mg - T = ma$$

$$T = m(g-a) = 24\ N$$

(42)



$$\tan\theta = \frac{ma}{mg}$$

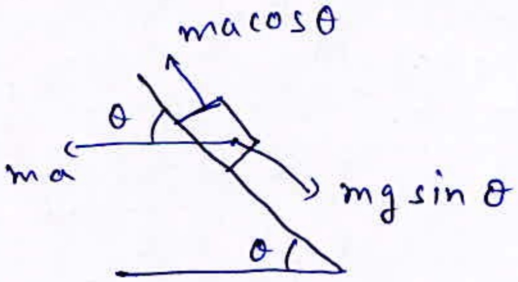
$$\theta = \tan^{-1}(a/g)$$

(43)

$$mg - N = ma$$

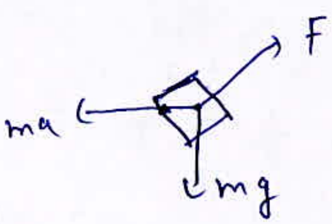
$$N = m(g-a) = 0$$

(44)



$$ma\cos\theta = mg\sin\theta \quad -(1)$$

$$F = m\sqrt{(a)^2+g^2} \quad -(2)$$



$$a = g\tan\theta$$

$$F = mg\sqrt{1+\tan^2\theta}$$

$$= mg\sec\theta$$

$$= mg/\cos\theta$$

(45)

$F \Delta t = \Delta m v \qquad \Delta t = 1$

$F_{max} = \frac{\Delta m v}{\Delta t} = \frac{n \times 40 \times 10^{-3} \times 1200}{1} = 144$

$n = 3$

(46)

$v^2 = u^2 + 2as$

$0 = (60)^2 + 2a\,(20 \times 10^{-3})$

$a = \frac{-(60)^2}{2 \times 20 \times 10^{-3}}$

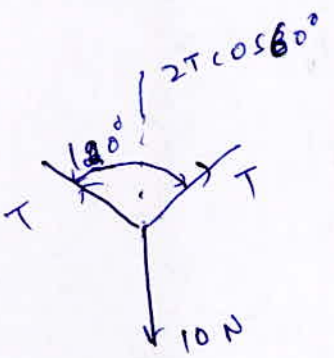
$0 = (120)^2 + 2a\,S_2$

$S_2 = \frac{-(120)^2}{2 \times \frac{-(60)^2}{2 \times 20 \times 10^{-3}}} = 80\text{ m}$

(47)

$N = mg + ma = 1125\text{ N}$

(48)



$2T \cos 60^\circ = 10\text{ N}$

$T = 10\text{ N}$

(49)

$$N = m(g+a)$$

(50)

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}} \qquad T_0 = 2\pi\sqrt{\frac{l}{g}}$$

$$T' = 2\pi\sqrt{\frac{l}{g/4}} = 2T$$

(51)

$$N = m(g+a) = 80(16) = 1280\ N$$

(52)

$$v = \cancel{u}^{\,0} + at$$

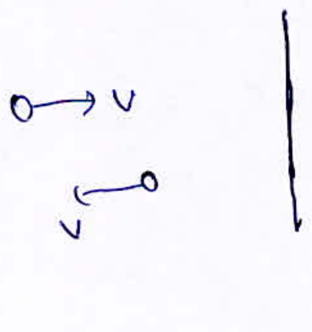
$$v = \frac{100}{5} \times 10 = 200\ cm/s$$

(53)

$$\vec{p} = m\vec{v} \qquad p_2 = m(2\vec{v})$$

$$p_2 = 2\vec{p}$$

(54)



$$|\Delta\vec{p}| = -mv - mv$$

$$= |-2mv|$$

$$= 2mv$$

(55)

$$F = \frac{\Delta mv}{\Delta t} = \frac{2mv}{t}$$

(56)

$$F = \frac{\Delta mv}{\Delta t} = \frac{2mnu}{1} = 2mnu$$

(57)

$$F_{swimmer} = - F_{water}$$

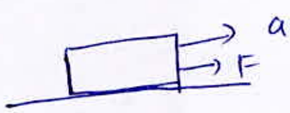
(58)

$$T_1 = T_2 = Mg$$

(59)

angle = 180°

(60)



$F = ma$ ~~B~~. action reaction

(61)

$F_{ext.} = 0$

(62)

$F_{ice} = - F_{man}$ action - reaction

Conservation of Linear Momentum Impulse

(1) $\frac{v^2}{R}$

(2)

$= |mv_f - mv_i|$

$= m \left| \frac{v}{\sqrt{2}}\hat{i} - \frac{v}{\sqrt{2}}\hat{j} - \frac{v}{\sqrt{2}}\hat{i} - \frac{v}{\sqrt{2}}\hat{j} \right|$

$= mv\sqrt{2}$

(3)

$\Delta t = 1$ sec.

$F \Delta t = \Delta(mv)$

$F = mv$

(4)

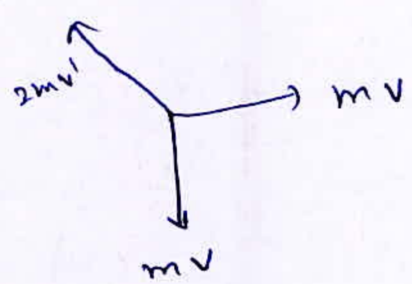
$F = 10 \times 10^{-3} (10 \times 500)$

$= 50$ N

$a = \frac{F}{200} = \frac{50}{200} = 0.25\ m/s^2 = 25\ cm/s^2$

(5)

$F_{ext} = 0$ momentum conservation



$2mv' = \sqrt{2}\, mv$

$v' = \frac{v}{\sqrt{2}}$

(6)

$F_{thrust} = \frac{\Delta mv}{\Delta t} = 50 \times 10^{-3} \times 400$

$= 20$ N

(7)

$F\Delta t = \Delta mv$ $\qquad \Delta t = 1\,sec.$

$F = Nmv$

(8)

$F\Delta t = \Delta mv$ $\qquad \Delta t = 1\,sec.$

$F = (0.1 \times 50)$

$a = \frac{F}{m} = \frac{5}{2} = 2.5\,m/s^2$

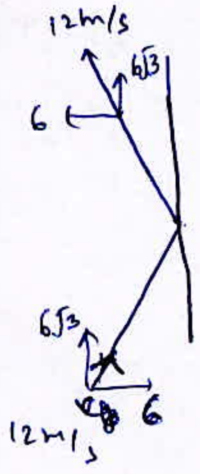
(9)

$F = \frac{\Delta mv}{\Delta t} = mg$

$5 \times \cancel{10^{-3}} \times 1\cancel{0} \times (v - (-v)) = 10\cancel{0} \times \cancel{10^{-3}} \times 9.8$

$v = 9.8\,m/s = 980\,cm/s$

(10)



$F\Delta t = \Delta mv$

$F = \frac{\Delta mv}{\Delta t}$

$= \frac{0.5 \times 2 \times 6}{0.25}$

$= 24\,N$

(11)

$F\Delta t = \Delta mv$

(12)

$F\Delta t = \Delta mv = 150 \times 10^{-3}(0 + 20 \times 0.1)$

$= 0.3\,N\text{-}s$

(13)

$$\Sigma \vec{F} = 0 = m\vec{a} \qquad \vec{a} = 0 = \frac{d\vec{v}}{dt} = 0$$

$$\vec{v} \equiv \text{constant}$$

(14)

$$F_{thrust} = \frac{\Delta mv}{\Delta t} = 4 \times 3000 = 12000 \text{ N}$$

(15)

$$\vec{F_{ext}} = 0 \qquad \Delta mv = 0$$

$$5 \times 10^{-3} \times 500 = 5 \times V$$

$$v = 0.5 \text{ m/s}$$

Equilibrium of forces.

①

$\cancel{|\vec{F_1} + \vec{F_2}| = 3}$

$|\vec{F_2}| = 2|\vec{F_1}|$ — ①

$F_1 + F_2 = 3F_1$ — ②

$|\vec{F_1} + \vec{F_2}| = 3|\vec{F_1}|$

$F_1^2 + F_2^2 + 2F_1F_2\cos\theta = 9F_1^2$

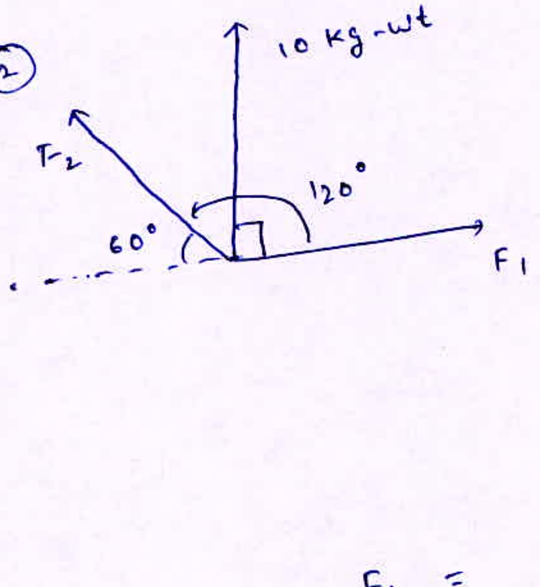
$F_1^2 + 4F_1^2 + 4F_1^2\cos\theta = 9F_1^2$

$4\cos\theta = 4$

$\cos\theta = 1$

$\boxed{\theta = 0^\circ}$ Ans.

②



$F_1 = F_2\cos 60^\circ$

$F_2 = 2F_1$

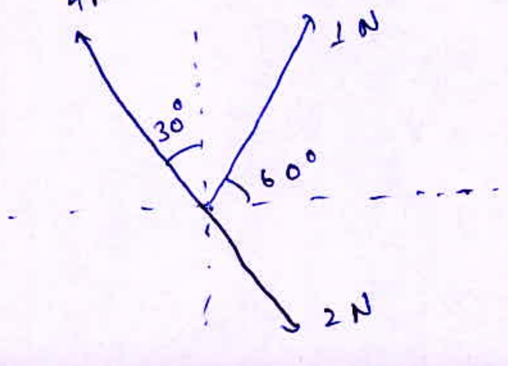
$10 \text{ kg-wt} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120^\circ}$

$= \sqrt{F_1^2 + 4F_1^2 - 4F_1^2 \times \frac{1}{2}}$

$= \sqrt{3}F_1$

$F_1 = \frac{10}{\sqrt{3}}$ kg-wt

③



$= 2\cos 60^\circ - 1\cos 60^\circ$

$= \cos 60^\circ$

$= 0.5$ N

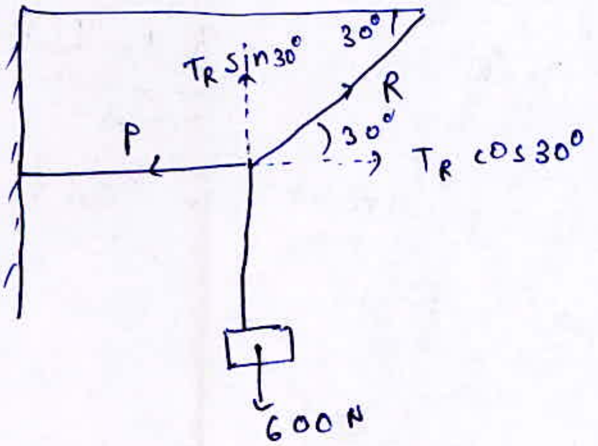
$\vec{F} = 0.5$ N Ans.

(4) $$|\vec{F_1} + \vec{F_2}|^2 = F^2 + F^2 + 2F^2\cos\theta = 3F^2$$

$$\cos\theta = \frac{1}{2}$$

$$\theta = \frac{\pi}{3}$$

(5)



$$T_R \sin 30° = 60g$$

$$T_R = 120g \text{ N}$$

$$T_P = T_R \cos 30°$$

$$= 120 \times \frac{\sqrt{3}}{2} g$$

$$= 103.9\ g \text{ N}$$

(6)

$$|\vec{F_1} + \vec{F_2}|^2 = F_1^2 + F_2^2 + 2F_1F_2\cos\theta$$

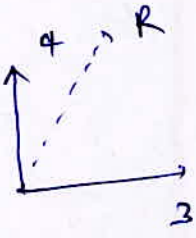
$$\Rightarrow F^2 + F^2 + 2F^2 \times \frac{1}{2} = (40)^2 \times 3$$

$$\Rightarrow 3F^2 = (40)^2 \times 3$$

$$\Rightarrow F^2 = (40)^2$$

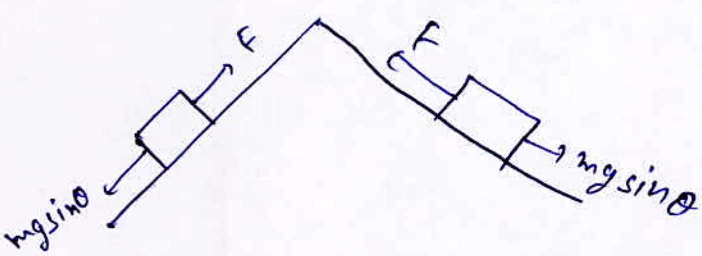
$$F = 40 \text{ N}$$

(7)

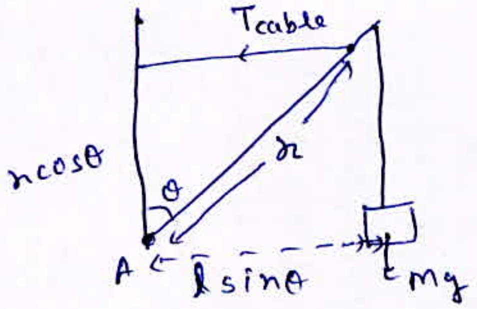


$$|\vec{R}| = \sqrt{3^2 + 4^2} = 5 \text{ N}$$

(8)



(9)



Torque Balance about A

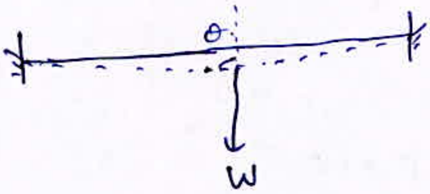
$$mgl\sin\theta = T_{cable} \times r\cos\theta$$

$$T_{cable} = \frac{mgl\tan\theta}{r}$$

For T_{cable} should be minimum $\Rightarrow$ r max.

r max. $= l$ Ans.

(10)



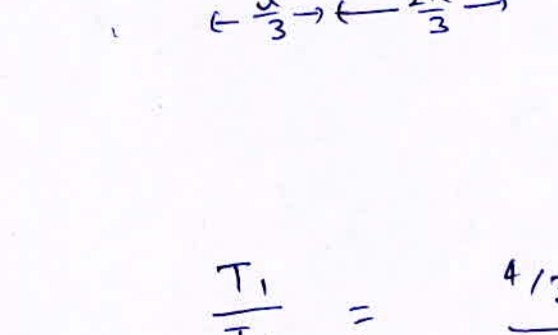
$$2T\cos\theta = W$$

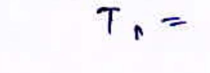
$$T = \frac{W}{2\cos\theta}$$

as $\theta \Rightarrow 90^\circ$ $\Rightarrow$ $T \to \infty$

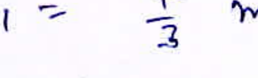
(11) $|\vec{R}| = \sqrt{2^2 + 2^2 + 2\cdot 2\cdot 2\cdot \cos 60^\circ} = \sqrt{12} = 2\sqrt{3}$ N

(12)





$$T_2 = m l\omega^2$$



$$T_1 - T_2 = \frac{m l\omega^2}{3}$$

$$T_1 = T_2 + \frac{m\omega^2 l}{3}$$

$$T_1 = \frac{4}{3} m\omega^2 l$$

$$\frac{T_1}{T_2} = \frac{4/3\, m\omega^2 l}{m\omega^2 l} = \frac{4}{3}$$

(13)

Sum of any two should be > third

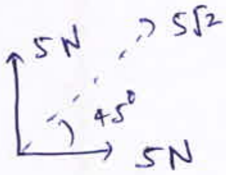
(d) $F_1 = 3N$, $F_2 = 5N$, $F_3 = 6N$

(14)

$\vec{F} = 0$ $\quad$ v unchanged

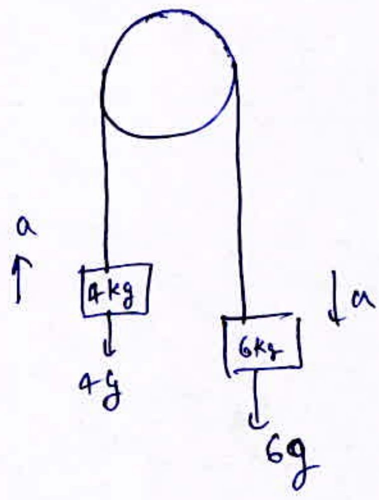
(15) ref. 13. ans. (a)

(16)



Motion of Connected Bodies and Friction

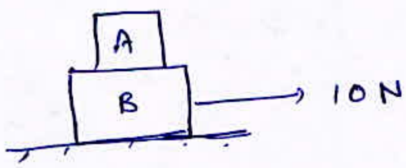
①



$$6g - 4g = (6+4)a$$

$$a = \frac{2g}{10} = \frac{g}{5}$$

②



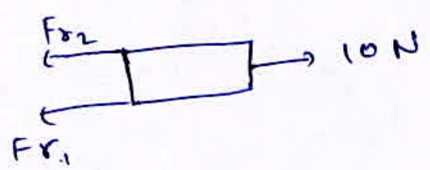
Fr_{max} btw. B and surface

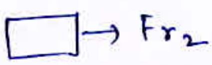
$= \mu (m_A + m_B) g$

$= 0.5 \times 10 \times 10$

$= 50\ N$

$a_{system} = 0$





$Fr_2 = m_A a = 0$

$Fr_1 = 10N$

③

$F = Fr = 10\ N$

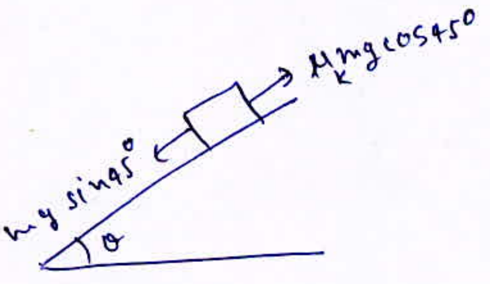
④

$\tan\theta = \mu_s$

$\tan 60^\circ = \mu_s$

$\Rightarrow \mu_K = ?$

⑤



$d = \frac{1}{2}\left(g/\sqrt{2} - \mu_K g/\sqrt{2}\right)(nt)^2$ —①

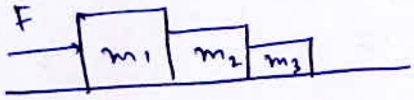
$d = \frac{1}{2}\, g/\sqrt{2}\ t^2$ —②

$(1-\mu_K)n^2 = 1$

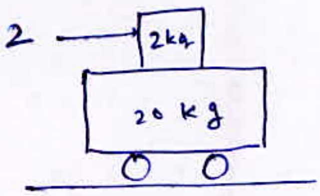
$\mu_K = 1 - 1/n^2$ Ans.

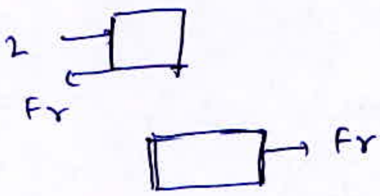
~~(6)~~ (7)

$$a = \frac{F}{m_1 + m_2 + m_3}$$



(8)





$$Fr_{max} = \mu N$$
$$= \frac{1}{4} \times 20$$
$$= 5N$$
$$a_{trolly\,max} = \frac{5}{20} = 0.25$$

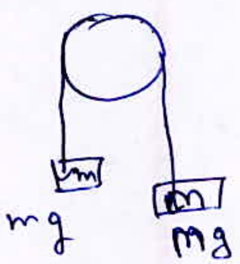
$$a_{system} = \frac{2}{22} = 0.09$$

check $\boxed{a_{system} \leq 0.25}$

(9)

$$v \text{ constant} \Rightarrow \frac{dv}{dt} = 0 \Rightarrow \vec{a} = 0 \Rightarrow \vec{F} = 0$$

(10)



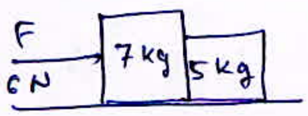
$$0.6 = \frac{1}{2} a t^2$$
$$0.6 = \frac{1}{2} a 4^2$$
$$a = \frac{3}{40}$$

$$a = \frac{(M - m)g}{M + m}$$

$$\frac{3}{400} = \frac{\left(1 - \frac{m}{M}\right)}{1 + \frac{m}{M}}$$

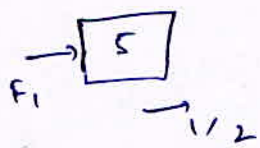
$$\frac{3 + 400}{397} = \frac{2}{2\frac{m}{M}} \Rightarrow \frac{m}{M} = \frac{397}{403}$$

(11)



$F = (7+5)\,a$

$a = \frac{6}{12} = \frac{1}{2}\ m/s^2$



$F_1 = 5 \times \frac{1}{2} = 2.5\ m/s^2$

(12)

$\cancel{v^2 = u^2 + 2as}$

$\cancel{0 = 6^2 + 2a}$

$v = u + at$

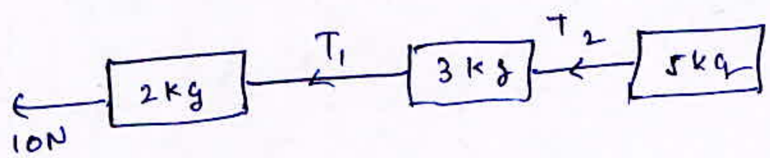
$0 = 6 + a \times 10$

$a = -0.6\ m/s^2$

$a = \frac{\mu m g}{m} = \mu g = 0.6$

$\mu = 0.06$

(13)



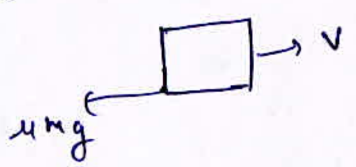
$10 = (2+3+5)\,a$

$a = 1\ m/s^2$

$T_1 = (3+5) \cdot 1 = 8N$

$T_2 = 5 \cdot 1 = 5N$

(14)



$v = u + at$

$0 = v - \mu g t$

$t = \frac{v}{\mu g}$

(15)

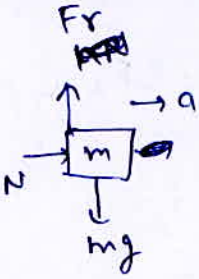
limiting friction $= \mu_s N$ $\quad \mu_s > \mu_K$

dynamic " $= \mu_K N$

(16)

$\mu_s > \mu_K$

(17)

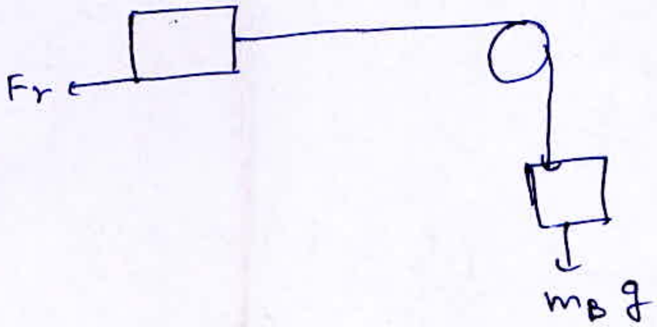


$N = ma$

$\mu ma > mg$

$\mu > g/a$

(18)



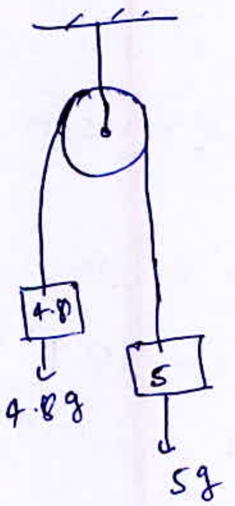
$m_B g < \mu m_A g$

$m_B < \mu m_A$

$m_B < 0.2 \times 2$

$m_B < 0.4$ kg

(19)



$(5 - 4.8) g = (5 + 4.8) a$

$0.2 g = 9.8 a$

$a = 0.2 \ m/s^2$

(20)

$4g = \mu_s N = \mu_s \times 10 \times 9.8$

$\mu_s = 5/10 = 0.5$

(21)

$a_{max} = -\mu g$

$v^2 = u^2 + 2as$

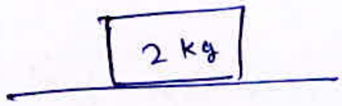
$0 = (72 \times \frac{5}{18})^2 - 2 \mu g s$

$s = \frac{(20)^2}{2 \times \frac{1}{2} \times g} = \frac{400}{g} = 40.8$ m.

(22)

$0 \leq Fr \leq \mu N$ remains the same

(23)



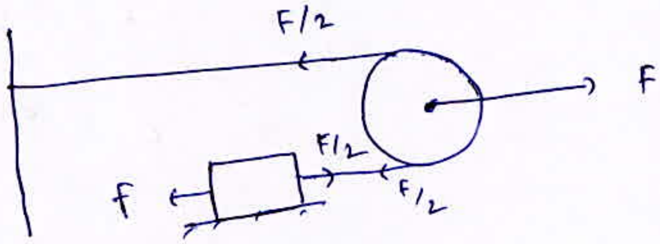
$$F_{r\,max} = \mu N = 0.2 \times 20 = 4\ N$$

if $F > 4$ body will move

(24)

Sliding Friction > Rolling Friction

(25)



$$\left(\frac{F}{2} - f\right) = ma$$

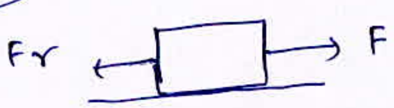
$$a = \left(\frac{F}{2} - f\right)/m$$

(26)

$F_r = 0.5 \times 100 = 50$

$a = (100 - 50)/10 = 5\ m/s^2$

(27)

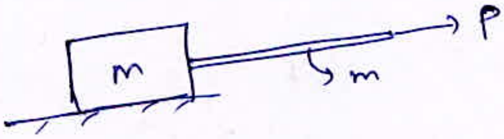


if $F > \mu_s N$ then $F_r = \mu_k N$

$\mu_s N = 0.5 \times 20 = 10\ N$

$F > 4\ N \Rightarrow F_r = \mu_k N = 0.4 \times 20$

(28)

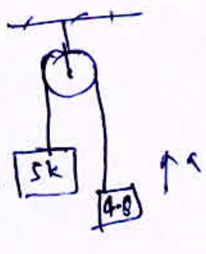


$$a = \frac{P}{M+m}$$

$\boxed{M} \to F \Rightarrow F = M \dfrac{P}{M+m}$

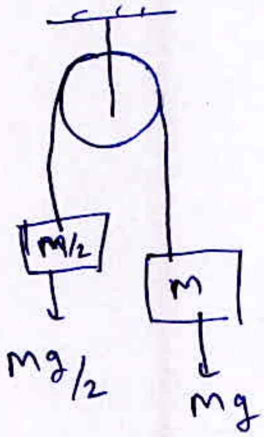
$$F = \frac{PM}{M+m}$$

(29)



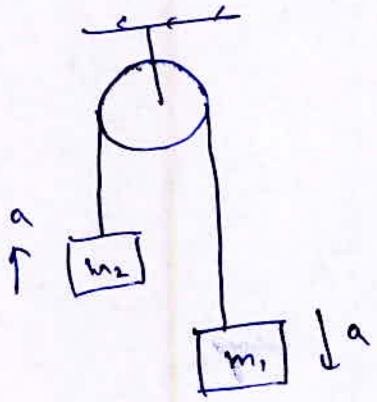
$$a = \frac{(5 - 4.8)g}{(5 + 4.8)} = 0.2\ m/s^2$$

(30)



$$a = \frac{mg - mg/2}{(m + m/2)} = g/3$$

(31)



$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

$$a_{cm} = \frac{m_1 a - m_2 a}{m_1 + m_2}$$

$$= \left(\frac{m_1 - m_2}{m_1 + m_2}\right) a$$

$$= \left(\frac{m_1 - m_2}{m_1 + m_2}\right)\left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$$

$$a_{cm} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 g$$

(32)

$$(\vec{A} + \vec{B}) \cdot (\vec{A} - \vec{B}) = 0$$

$$A^2 - B^2 + \cancel{\vec{B}\cdot\vec{A}} - \cancel{\vec{A}\cdot\vec{B}} = 0$$

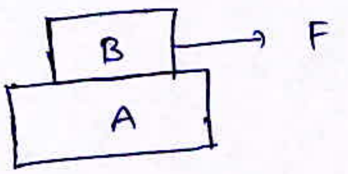
$$A^2 - B^2 = 0$$

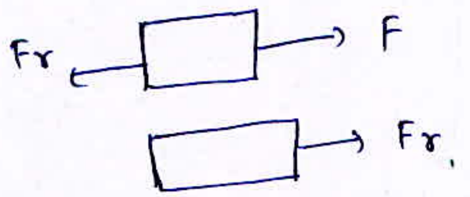
$$A^2 = B^2$$

$$|\vec{A}| = |\vec{B}|$$

Graphical Questions.

(1)





$$a_{A\,max} = \frac{Fr_{max}}{m_A} = \frac{\mu m_B g}{m_A}$$

$$a_B = \frac{F - Fr}{m_B}$$

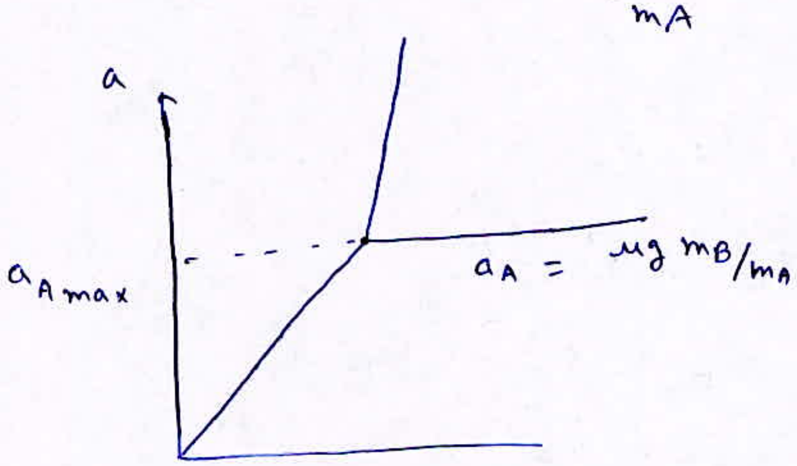
(1) $a_B \leq a_{A\,max}$

$$a_A = a_B = \frac{F}{m_A + m_B}$$

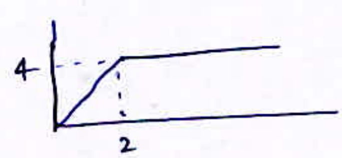
(2) $a_B > a_{A\,max}$

$$a_B = \frac{F - \mu . m_B g}{m_B}$$

$$a_A = \frac{\mu m_B g}{m_A} = \mu g \frac{m_B}{m_A}$$



(2)

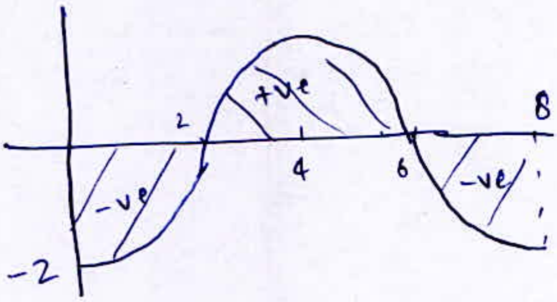


$v_f = 0$

$v_i = \frac{4}{2} = 2$

$$F \Delta t = \Delta mv$$
$$= 0.1(0-2)$$
$$= -0.2 \text{ kg m/sec.}$$

(3)

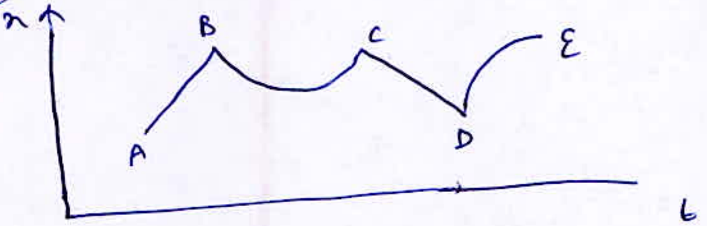


$\Delta mv = F \Delta t$

$$\int_{P_i}^{P_f} d\vec{P} = \int_0^8 F \, dt$$

$P_f - P_i = 0$

(4)



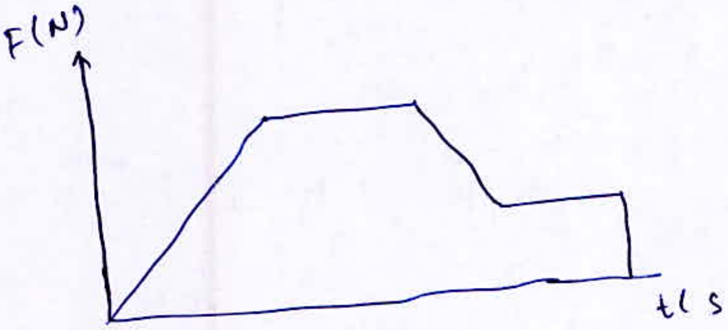
$F = ma$

$= m \dfrac{d^2x}{dt^2}$

$\dfrac{d^2x}{dt^2} = 0$

$\dfrac{d^2x}{dt^2} = 0 \Big|_{AB \,\&\, CD}$

(5)



$\int d\vec{P} = \int F \, dt$

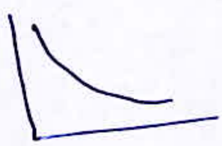
$m(v_f - v_i) =$ area of F-t graph

$m(v_f - 5) = 18.5$

$v_f = \dfrac{18.5}{2} + 5 = 14.25$ m/s

(6)

$k \propto \dfrac{1}{l}$



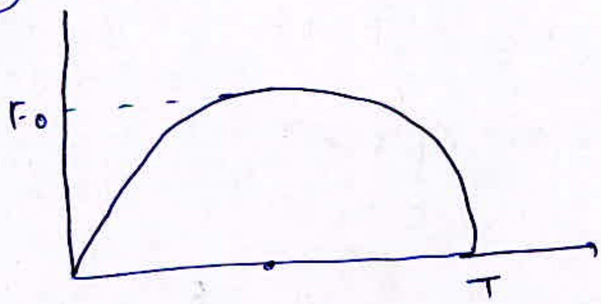
(7)

(m) $\rightarrow u$ (m) after collision (m) (m) $\rightarrow u$

$\Delta P = \int_0^T F \, dt = \frac{1}{2} F_0 T$

$mu = \frac{1}{2} F_0 T \Rightarrow F_0 = \dfrac{2mu}{T}$

(8)

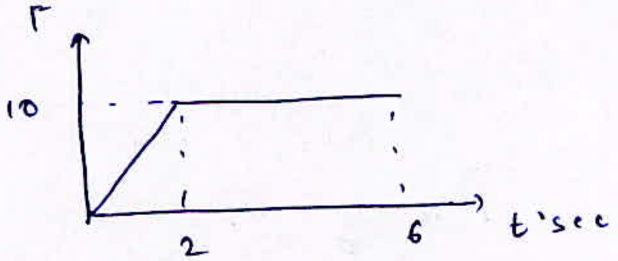


$$\Delta\vec{p} = \int_0^T F\,dt$$

$$mu - 0 = \frac{\pi}{4} F_0 T$$

$$u = \frac{\pi F_0 T}{4m}$$

(9)

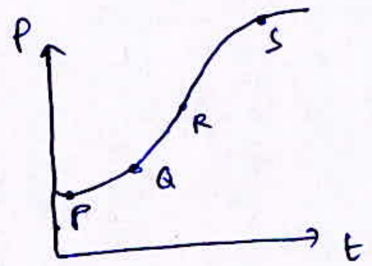


$$\Delta p = \int_0^6 F\,dt$$

$$mu - 0 = 50$$

$$mu = 50\ N\text{-}s$$

(10)



$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{F}_{max} = \left.\frac{d\vec{p}}{dt}\right|_{max}$$

from graph slope is max. at R

(11)

$$\text{Impulse} = \int_0^t F\,dt$$

area of F-t curve is max ~~of~~ for III & IV.