Laws of Motion

Force

① Gravitational Force

② Electromagnetic Force

③ Strong Nuclear Force

④ Weak Nuclear Force

GF < WF < EMF < SF

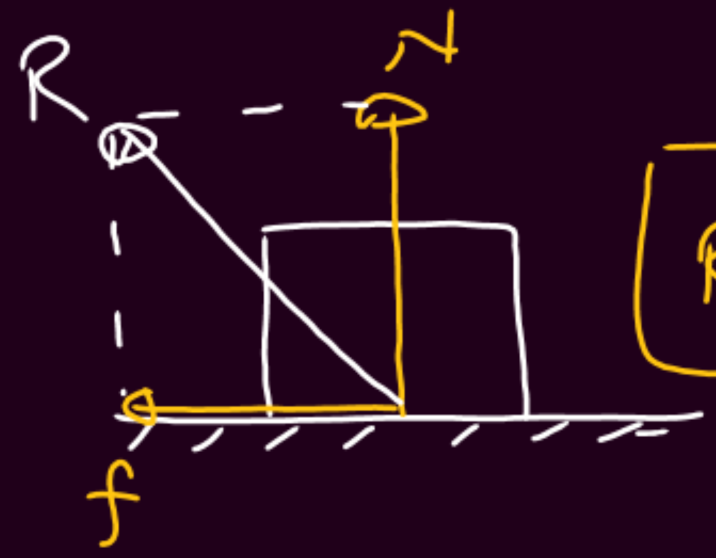
$F = 2g = 20\,N$

$= 2$ kg-wt

① mg (weight) — Vertically Downwards

② Tension in String (T) — Towards the string

③ Contact / Reaction Force

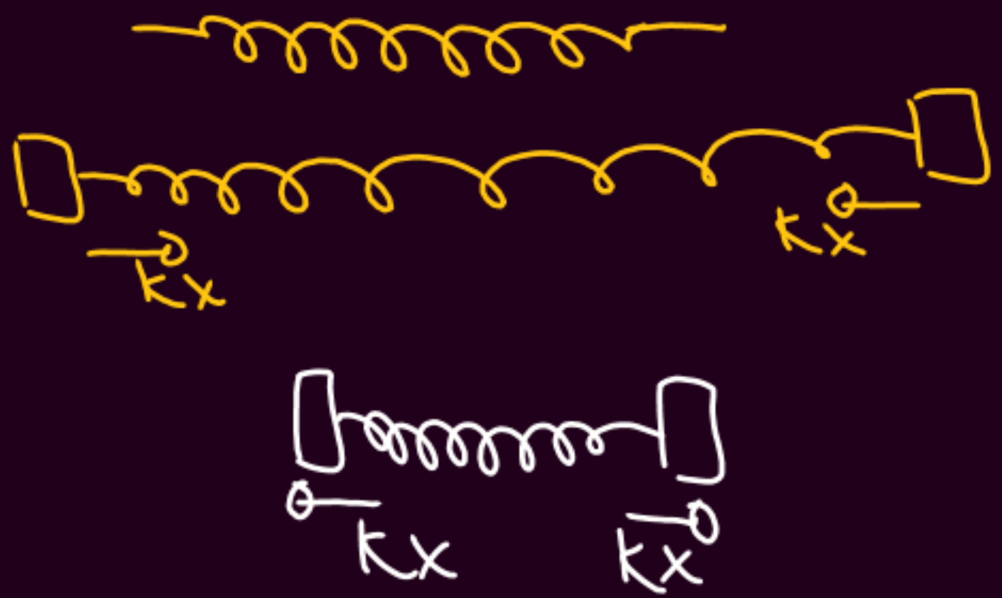


$$\boxed{R = \sqrt{N^2 + f^2}}$$

- Normal Reaction (N) → Towards the object
  "component of R ⊥ to surface"
- Friction "Component of R along the Surface"

④ Spring

$$\boxed{F = -kx}$$

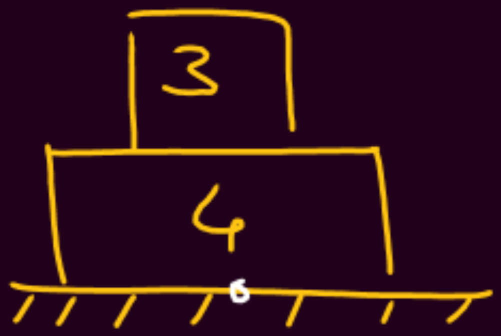


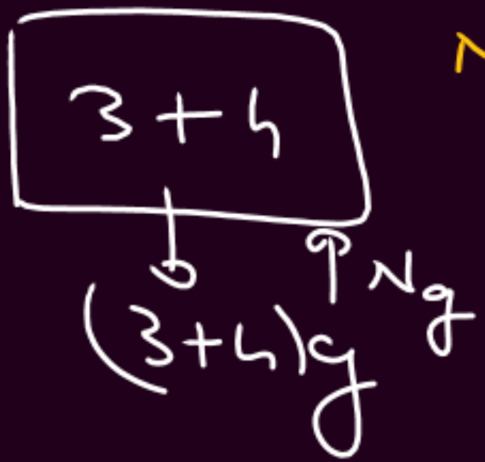
(Elongation)

(Compression)

Equilibrium $\boxed{\vec{F}_{net} = 0}$

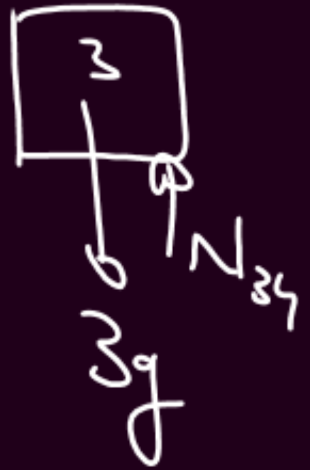
$\boxed{N = 5g}$

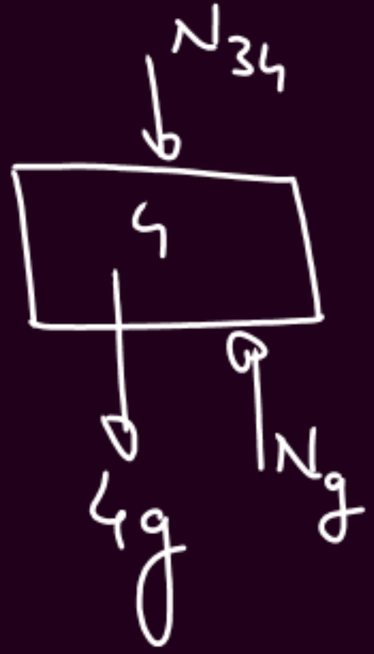




$N_g = (3+4)g$

$N_{34} = 3g$

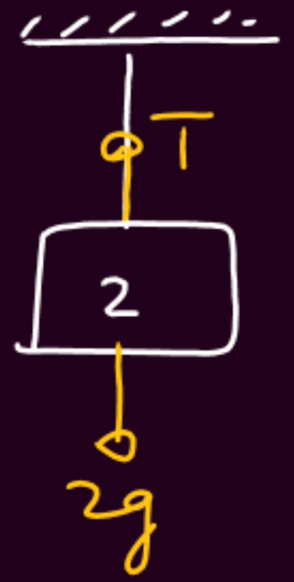




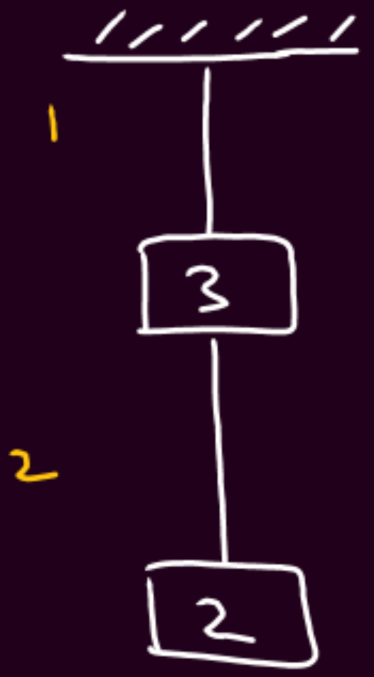
$N_g = 4g + N_{34}$

Ideal String → massless (T same at all points)

→ inextensible



$\boxed{T = 2g}$

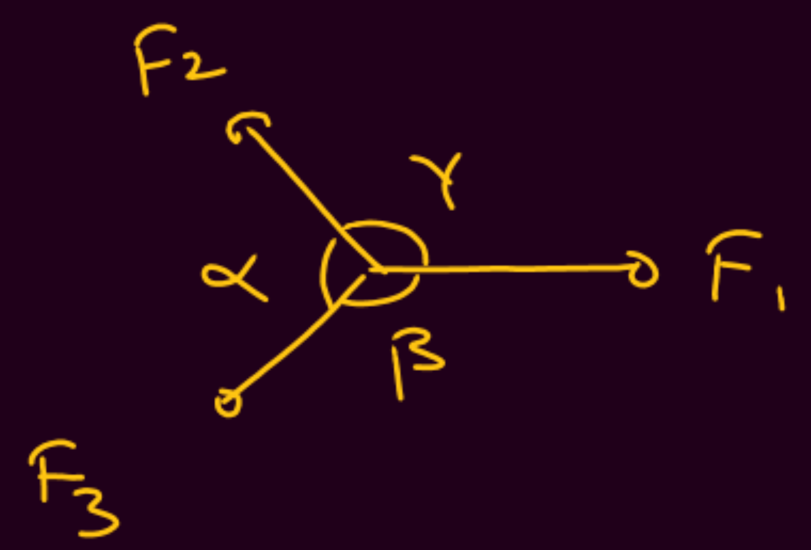


$\boxed{T_2 = 2g}$

$\boxed{T_1 = 5g}$

Lami's Theorem

$\rightarrow \vec{F_1} + \vec{F_2} + \vec{F_3} = 0$



$$\boxed{\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}}$$

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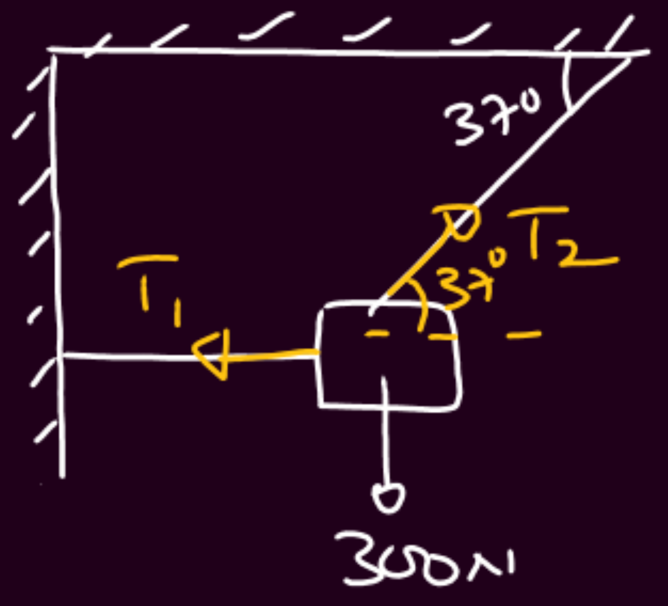
(3)



$$\frac{T_1}{\sin(90^\circ+37^\circ)} = \frac{T_2}{\sin 90^\circ} = \frac{300}{\sin(180^\circ-37^\circ)}$$

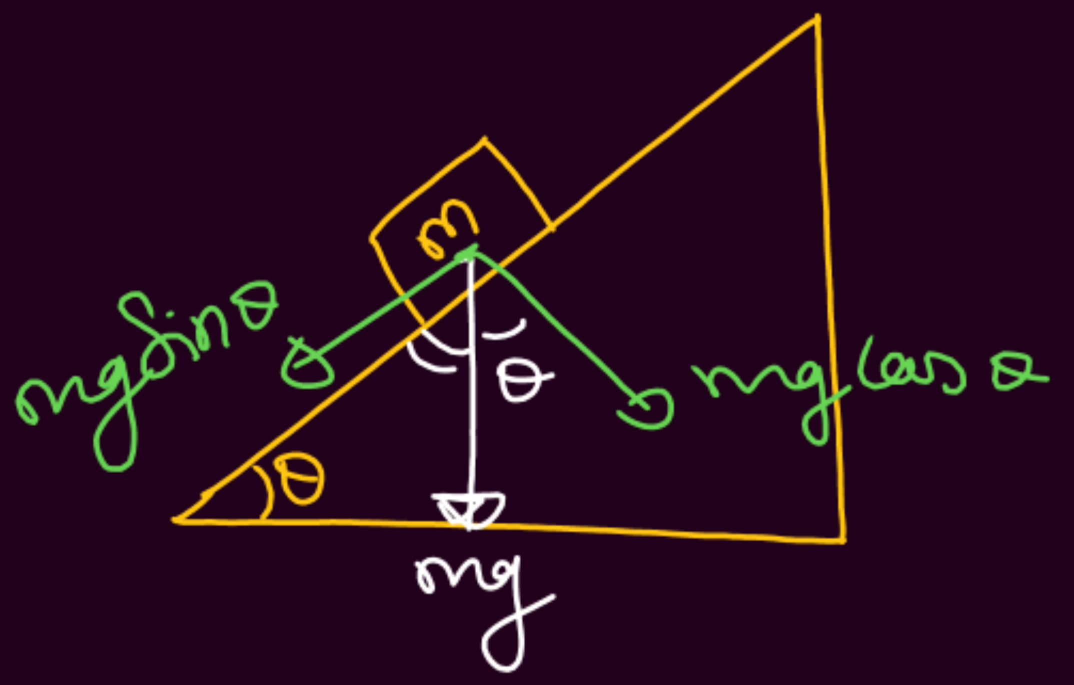
$$\frac{T_1}{\cos 37^\circ} = \frac{T_2}{1} = \frac{300}{\sin 37^\circ}$$

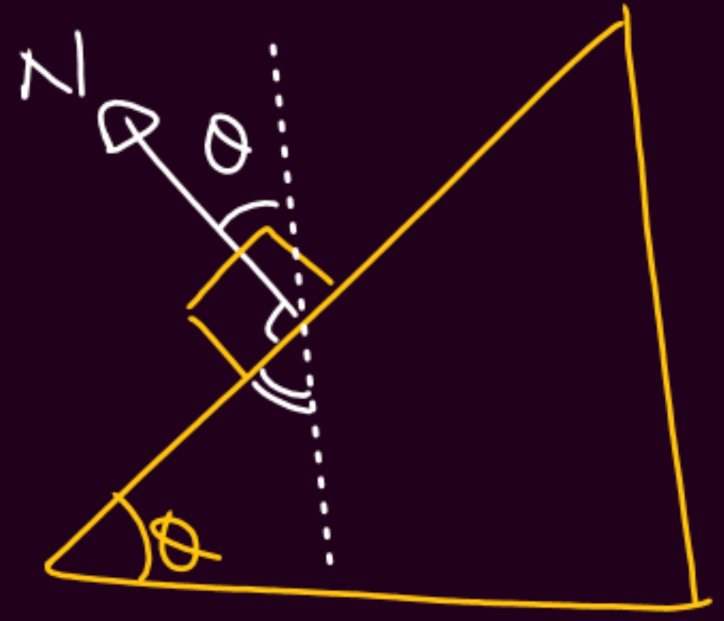
$$\frac{T_1}{4/5} = T_2 = \frac{300}{3/5}$$

$T_1 = 400\,N$

$T_2 = 500\,N$

Incline Plane





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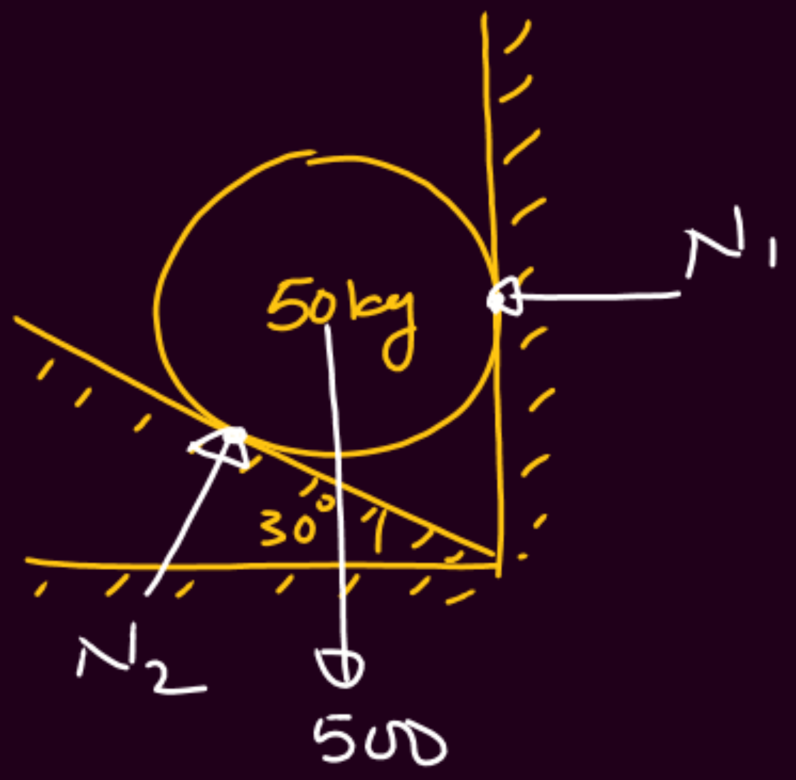
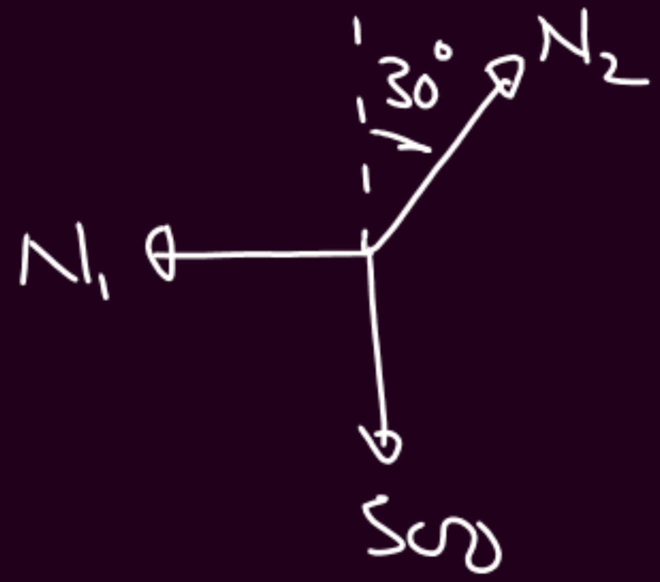
(2)



$$\frac{N_1}{\sin(180^\circ-30^\circ)} = \frac{N_2}{\sin(90^\circ)} = \frac{500}{\sin(90^\circ+30^\circ)}$$

$$\frac{N_1}{\sin 30^\circ} = \frac{N_2}{1} = \frac{500}{\cos 30^\circ}$$

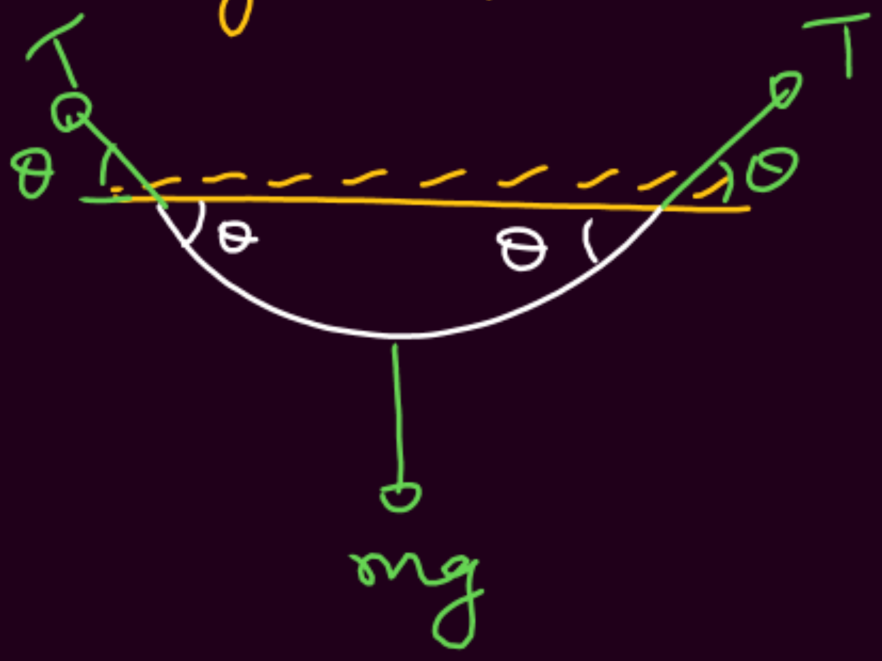
$$\frac{N_1}{1/2} = N_2 = \frac{500}{\sqrt{3}/2}$$



$$N_1 = \frac{500}{\sqrt{3}}\ N$$

$$N_2 = \frac{1000}{\sqrt{3}}\ N$$

Heavy Rope



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

$\theta \to 0$ $\quad T \to \infty$

① F req to keep a rope Horizontal is ∞

② It is impossible to keep the rope Horizontal

③ 

To have min strain

[Arms must be parallel]

Newton's laws of Motion

① 1st Law (Law of Inertia)

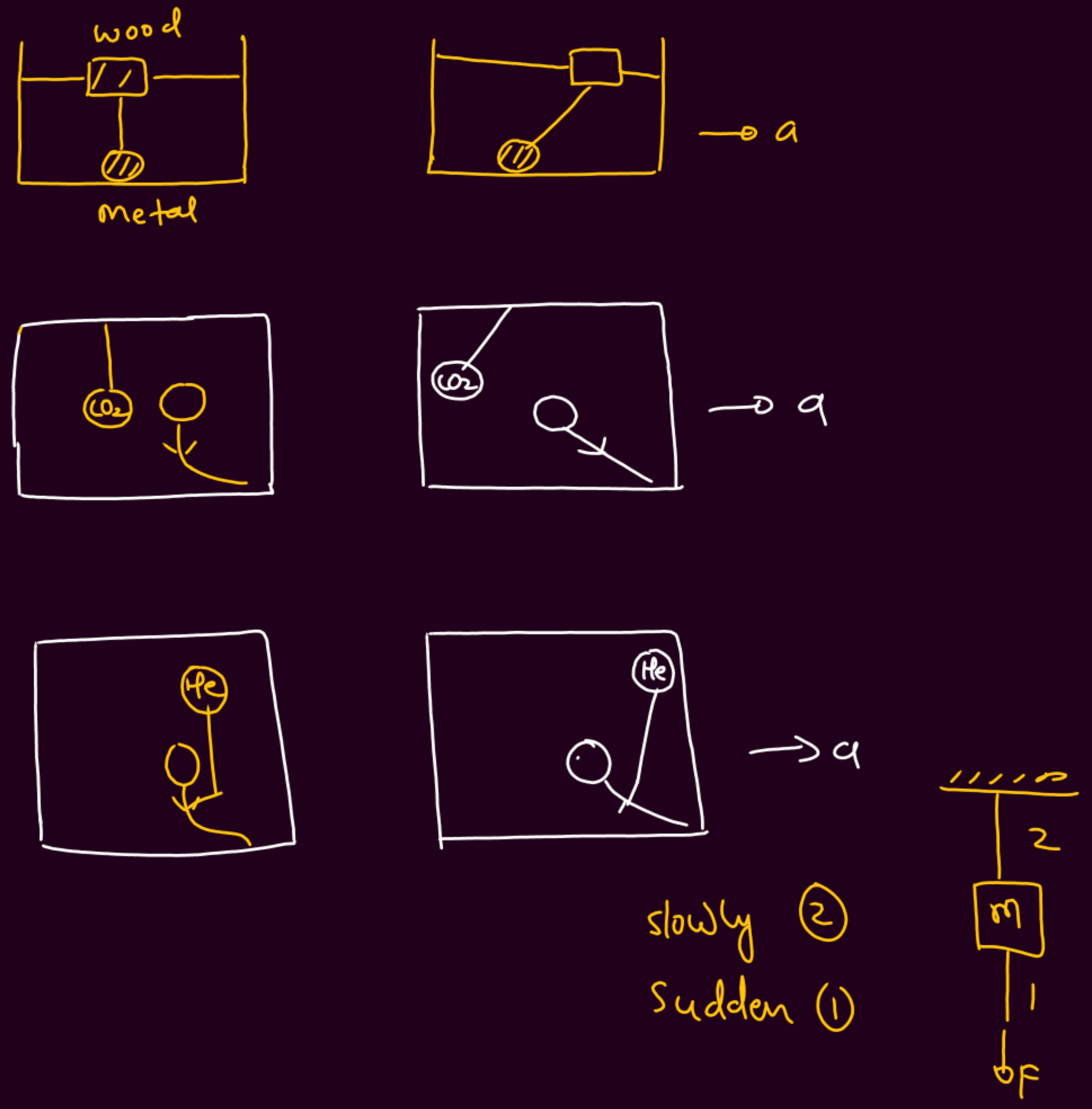
Rest → Rest } untill $\vec{F}_{ext}$
Motion → $\vec{v}$ = const

$$\boxed{\text{if } \vec{F}_{ext} = 0 \text{ then } \vec{v} = \text{const} \quad \& \text{ vice versa}}$$

Inertia → Opposses the change in $\vec{v}$

→ Proportional to mass

- → Rest
- → motion
- → Direction



Momentum $\vec{p} = m\vec{v}$

$$K = \frac{1}{2} m v^2 = \frac{p^2}{2m}$$

$$p = \sqrt{2mK}$$

2^{nd} Law

$$\boxed{\vec{F}_{ext} = \frac{d\vec{p}}{dt}}$$

$$F_{av} = \frac{\Delta p}{\Delta t}$$

① if m = const. $\boxed{F = m a}$

② m ⇒ variable
v = const. $\boxed{F = v\frac{dm}{dt}}$

Conveyor Belt

$$F = v\frac{dm}{dt}$$

$$F = (5)(2) = 10\,N$$

Q. $\vec{F} = (3\hat{i} - 4\hat{j} + 5\hat{k})\,N$

$m = 5\,kg$ mag. of acc. ?

$$a = \frac{F}{m} = \frac{\sqrt{3^2+4^2+5^2}}{5} = \frac{5\sqrt{2}}{5} = \sqrt{2}\ m/s^2$$

Impulse

$$\Delta\vec{p} = m(\vec{v}_2 - \vec{v}_1) = \int \vec{F}\,dt$$

Impulse

Work

→ large force

↳ shorter period

Gravitational
Spring
} non-impulsive

	General / Inelastic	Perfectly Inelastic	Elastic — Normal incidence	Elastic — oblique
				
Change in Vel.	$(v_2 + v_1)$	v	$2v$	$2v\cos\theta$
Avg. Acc.	$a_{av} = \dfrac{v_2 + v_1}{t}$	$a_{av} = \dfrac{v}{t}$	$a_{av} = \dfrac{2v}{t}$	$a_{av} = \dfrac{2v\cos\theta}{t}$
Avg. Force	$F_{av} = \dfrac{m(v_2 + v_1)}{t}$	$F_{av} = \dfrac{mv}{t}$	$F_{av} = \dfrac{2mv}{t}$	$F_{av} = \dfrac{2mv\cos\theta}{t}$

Deviation $\delta = 180^\circ - 2\theta$

Q. Dropped 20m

Same height

$\Delta t = 0.2\,s$

then $a_{av} = ?$

$$v = \sqrt{2(10)(20)} = 20\,m/s$$

$$a_{av} = \frac{2v}{\Delta t} = \frac{2\times 20}{0.2} = 200\,m/s^2$$

Q. Dropped 45m to 20m

$m = 2\,kg \qquad \Delta t = 0.5\,s$

$$v_1 = \sqrt{2(10)(45)} = 30\,m/s$$

$$v_2 = \sqrt{2(10)(20)} = 20\,m/s$$

① Impulse

$$\Delta p = m\,\Delta v = (2)[30 + 20] = 100 \quad N\text{-}s$$

② $F_{av} = \dfrac{\Delta p}{\Delta t} = \dfrac{100}{0.5} = 200\ N$

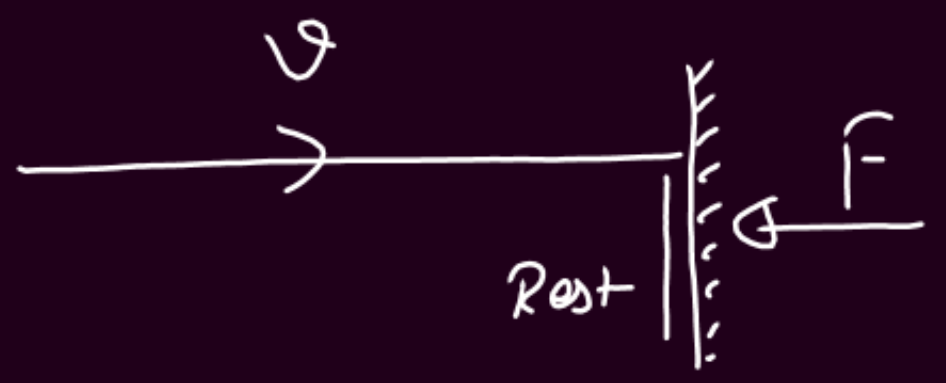
Fluid

① Vol. flow Rate

$$\boxed{\frac{dV}{dt} = A v}$$

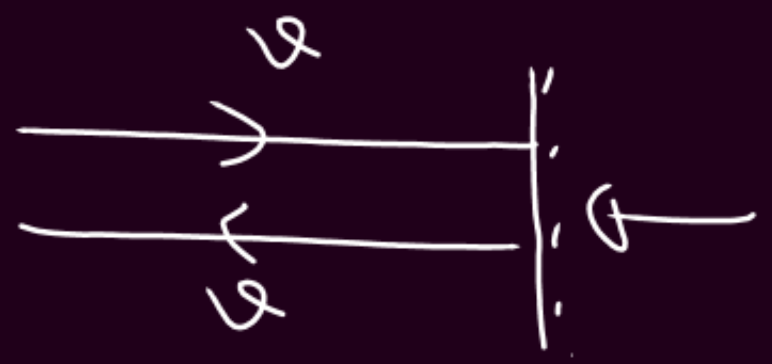
② Mass flow rate

$$\boxed{\frac{dm}{dt} = \rho A v}$$



$$F = v\frac{dm}{dt}$$

$$\boxed{F = \rho A v^2}$$



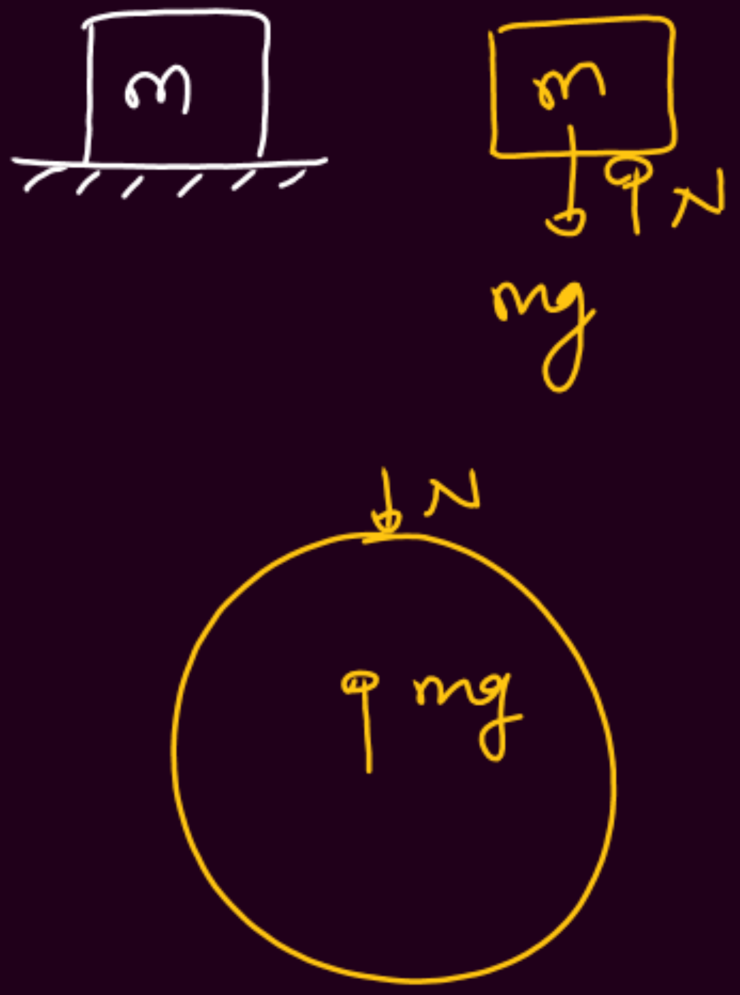
$$\boxed{F = 2\rho A v^2}$$

force req. to hold the plate

Newton's 3rd Law

$$\boxed{\vec{F}_{BA} = -\vec{F}_{AB}}$$

- Different objects
- Simultaneously
- Any Action / Reaction
- Same type
- Pairs



Examples

- Swimming
- Gun - Bullet
- Birds
- 
- [α - emission]
- Walking / Running

Case Machine Gun

N in t

$n = \frac{N}{t}$ = no. of Bullets per sec

Recoil force $= \frac{Nmv}{t} = nmv$

Case Disc

Rest

① After collision → Rest

$$Mg = nmv$$

② Rebounds with same speed

$$Mg = 2nmv$$

Q. Machine Gun

100 bullets /min

each [10g, 500 m/s]

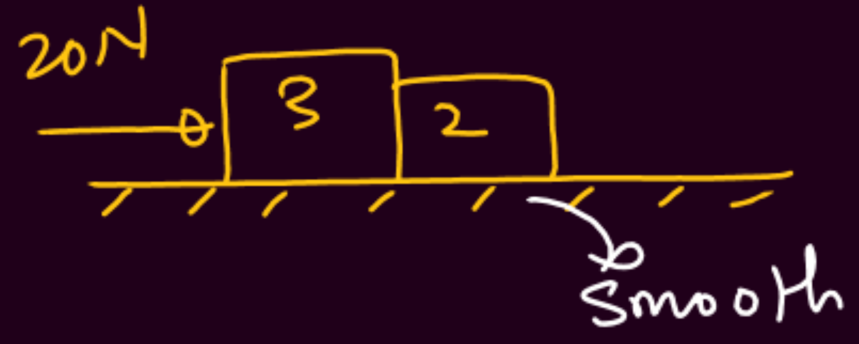
$F = ?$

$$F = \frac{Nmv}{t}$$

$$F = \frac{100 \times 10 \times 500}{1000 \times 60} = \frac{25}{3}\ N$$

Bodies in contact

Q.



① $a = \frac{20}{3+2} = 4\, m/s^2$

② N_{23}

$N = 2a = 8\,N$

$20 - N = 3a$

Q.

① $a = \frac{30}{6+3+1} = 3\, m/s^2$

② F_{net} on 3kg $= ma = 3(3) = \underline{\underline{9N}}$

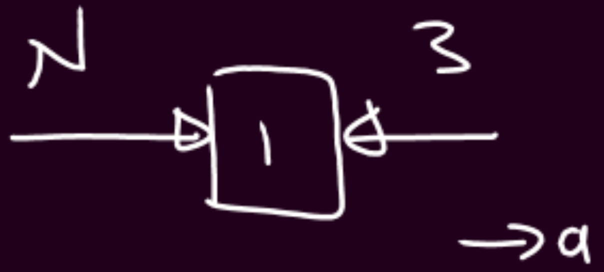
③ Force exerted by 6 kg on 3kg

$N = (3+1)(3) = \underline{\underline{12\,N}}$

Pg-160

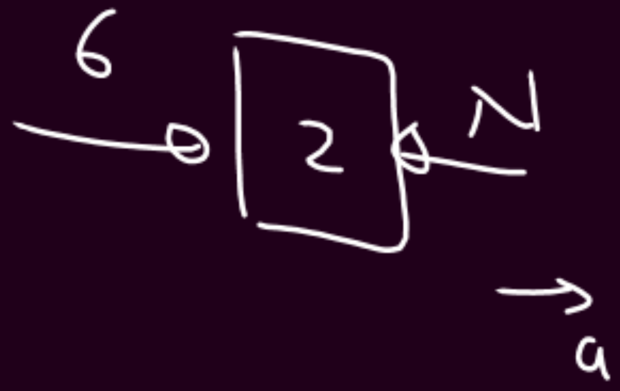
7

$$a = \frac{6-3}{2+1} = 1\,m/s^2$$



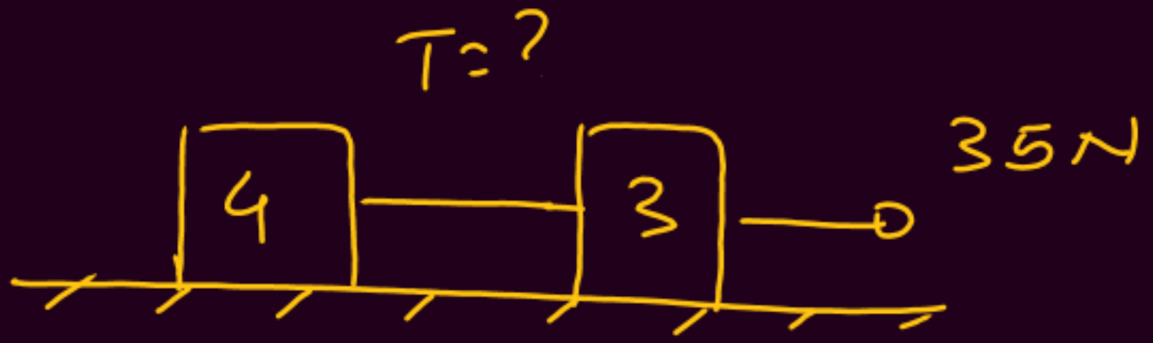
$$N - 3 = 1a$$

$$\underline{\underline{N = 4}}$$

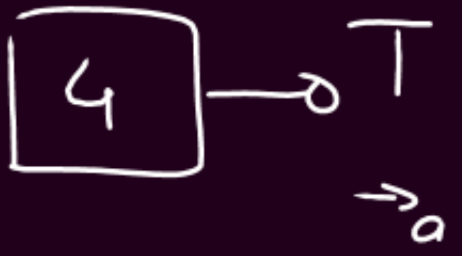


$$6 - N = 2a$$

$$\underline{\underline{N = 4}}$$

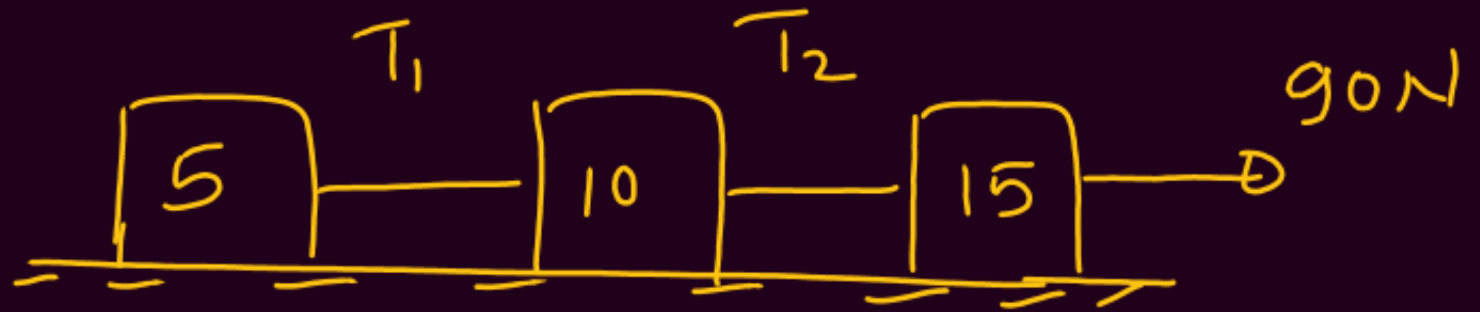


$$a = \frac{35}{4+3} = 5\,m/s^2$$



$$T = 4(5) = \underline{20N}$$

Q.



$$a = \frac{90}{5+10+15} = 3\ m/s^2$$

$$T_1 = 5(3) = 15N$$

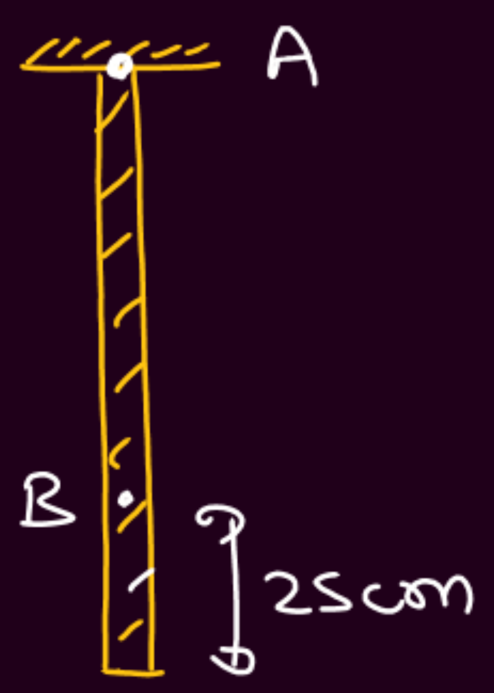
$$T_2 = (5+10)(3) = 45N$$

$$T_2 - T_1 = 10(a)$$

$$T_2 - 15 = 10 \times 3$$

$$\underline{T_2 = 45N}$$

Heavy Rope [Uniform]



① $T_A = 2g = 20N$

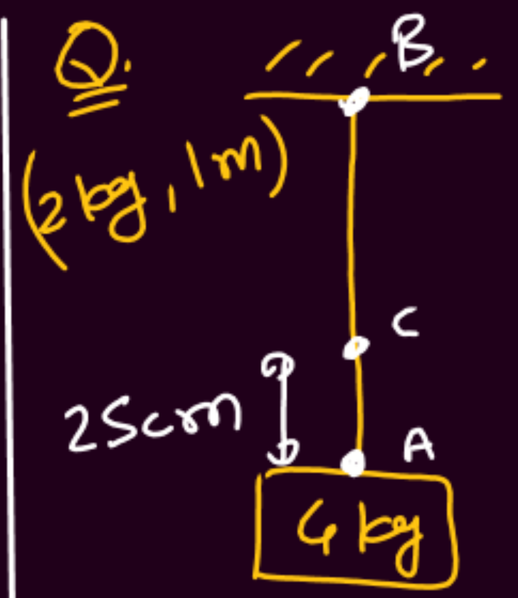
② $T_B = 0.25g = 2.5N$

(2kg, 2m)

$2m \rightarrow 2kg$

$0.25m \rightarrow \left(\frac{2}{2} \times 0.25\right) kg$

Q.



$T_A = 4g = 40N$

$T_B = 6g = 60N$

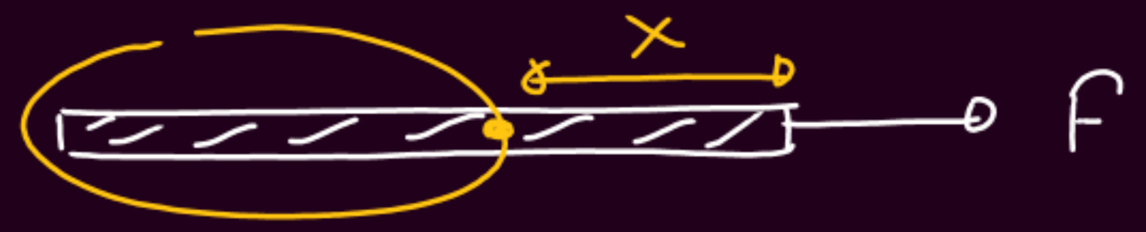
$T_C = (4 + 0.5)g = 45N$

$100 \rightarrow 2kg$

$25 \rightarrow \frac{2}{100} \times 25 = \underline{0.5 \; kg}$

Py-127

5



$$a = \frac{F}{M}$$

$$T = \frac{M}{L}(L-x)a = \frac{F(L-x)}{L}$$

Py-160

11

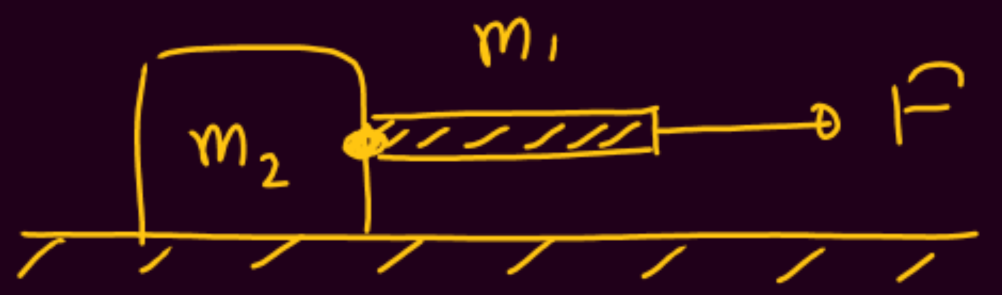
$$a = \frac{200 - 16g}{16} = 2.5\ m/s^2$$

$$200 - 70 - T = 7(2.5)$$

$$130 - T = 17.5$$

$$\boxed{T = 112.5\ N}$$

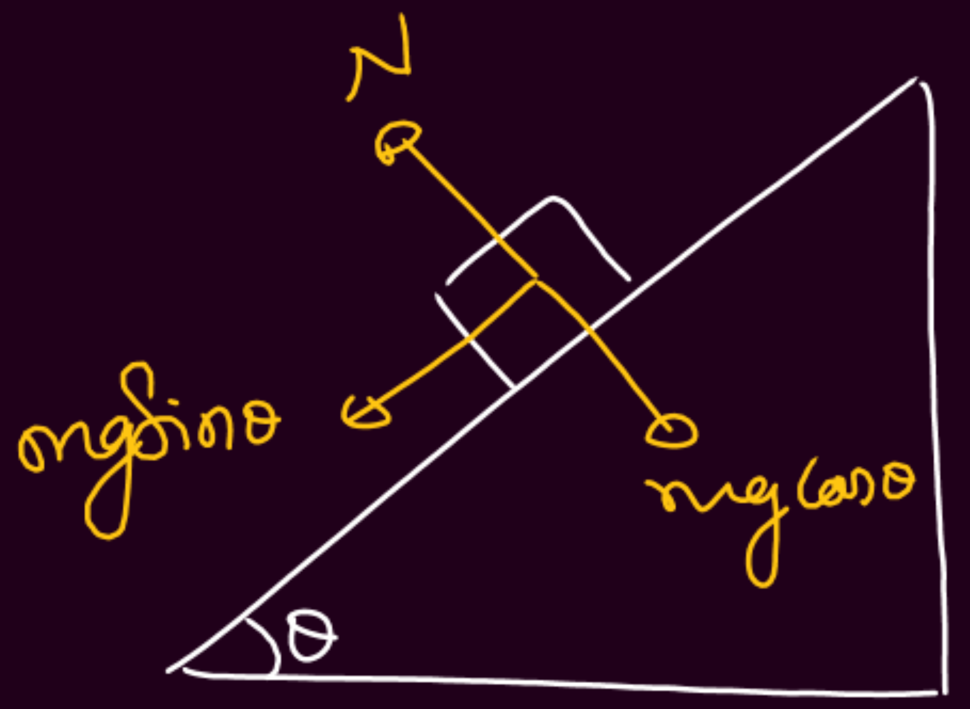
Q



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

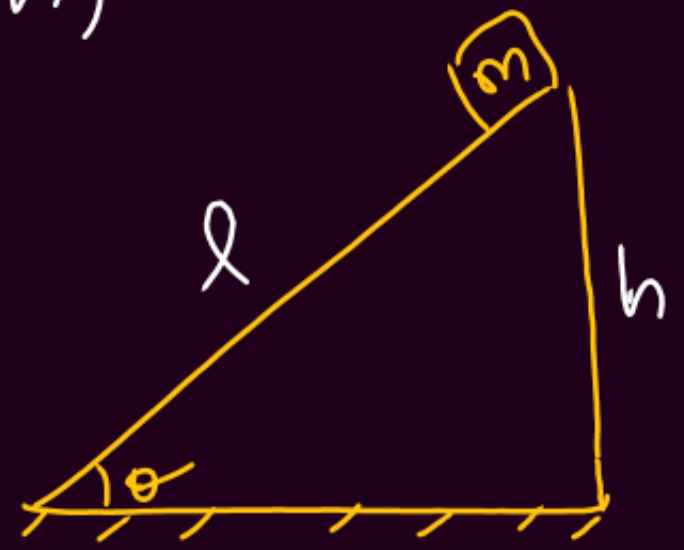
$$T = m_2 a = \frac{m_2 F}{m_1 + m_2}$$

Inclined Plane (Smooth)



① $N = mg\cos\theta$

② $a = g\sin\theta$



① $a = g\sin\theta$

② $v = \sqrt{2gh}$

$$v = \sqrt{2(g\sin\theta)\frac{h}{\sin\theta}}$$

③ $t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$

$$\frac{h}{\sin\theta} = \frac{1}{2} g\sin\theta\, t^2$$

free fall

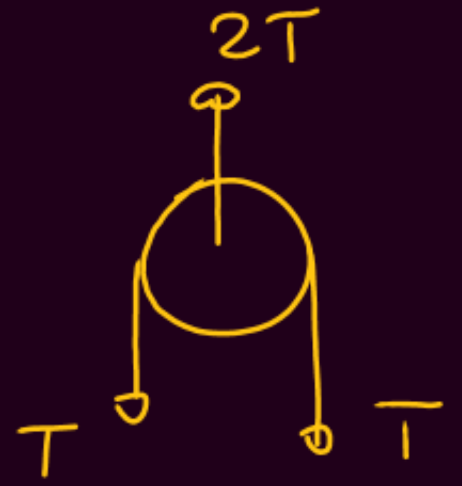
$a = g$

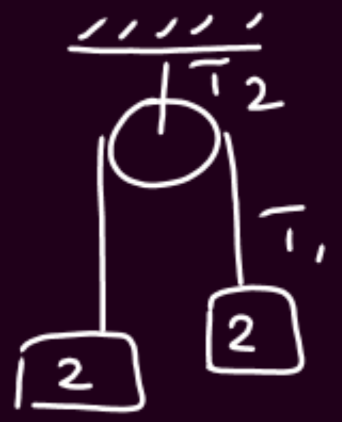
$v = \sqrt{2gh}$

$t = \sqrt{\frac{2h}{g}}$

Pulley

Ideal → massless
→ frictionless





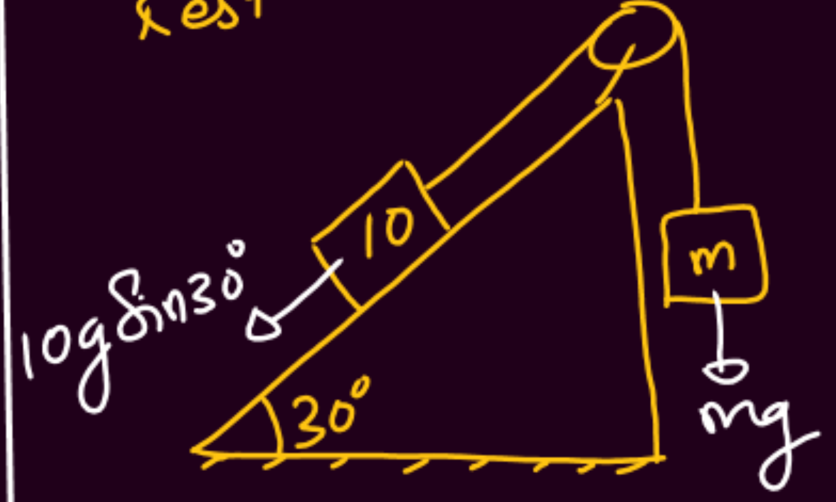
$a = 0$

Rest

$T_1 = 2g$

$T_2 = 2T_1 = 4g$

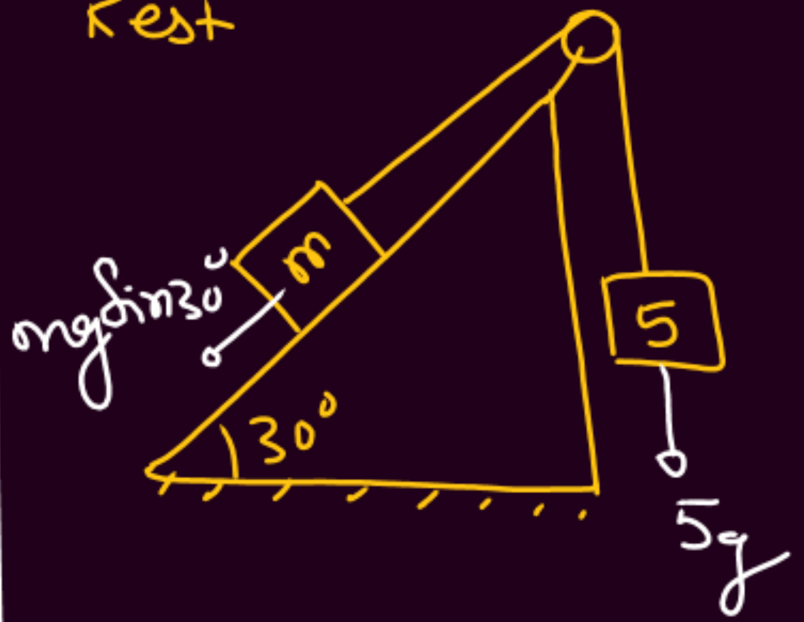
Rest



$mg = 10g\sin 30°$

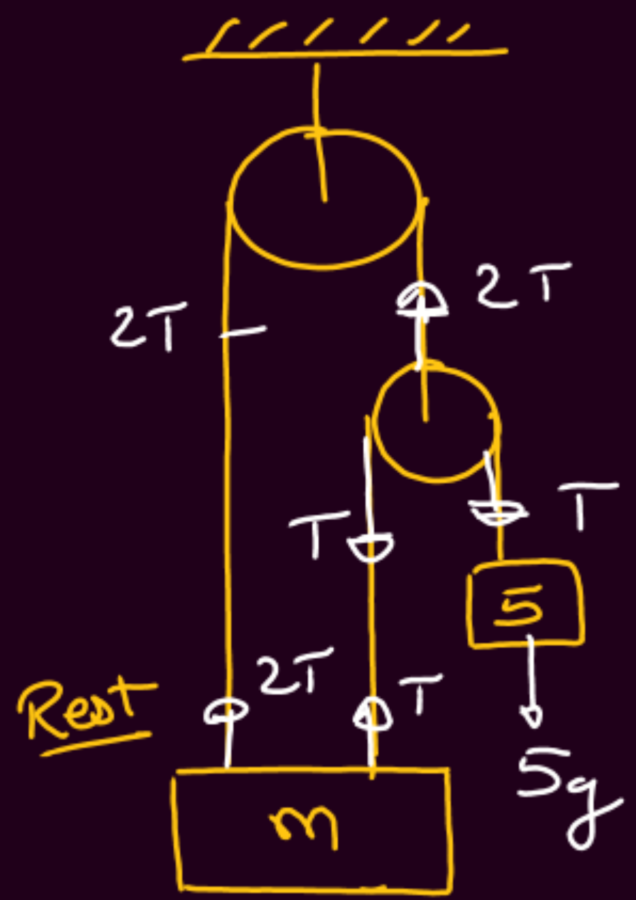
$m = 5\text{ kg}$

Rest



$mg\sin 30° = 5g$

$\boxed{m = 10\text{ kg}}$

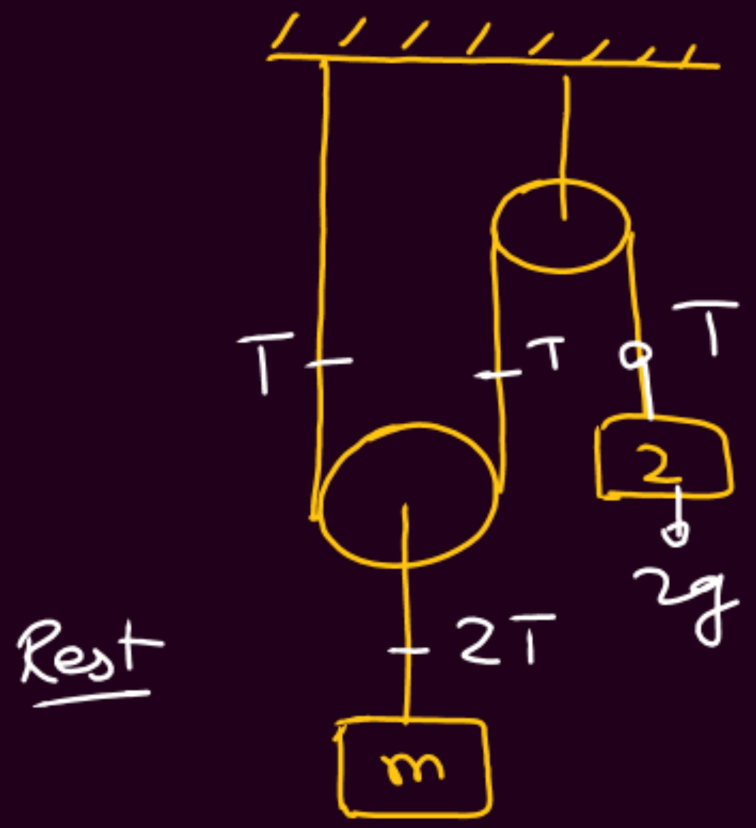


① $T = 5g$

② $2T + T = mg$

$15g = mg$

$m = 15\,kg$



① $T = 2g$

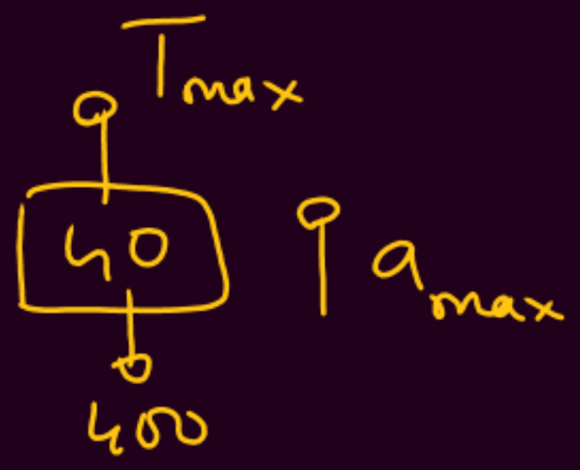
② $2T = mg$

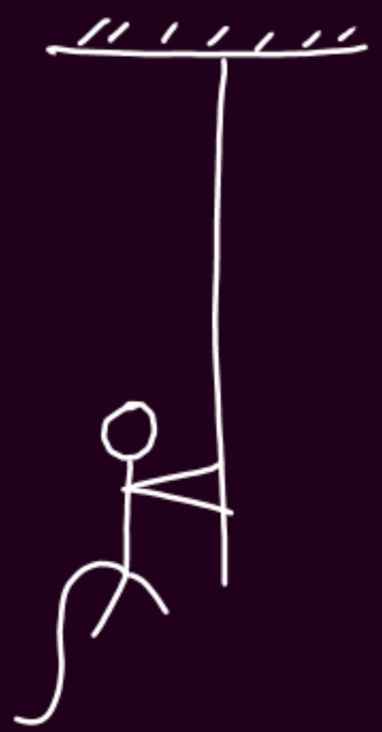
$m = 4\,kg$

Monkey - Rope

Q Rope $\longrightarrow$ 600 N

$m = 40\,kg$





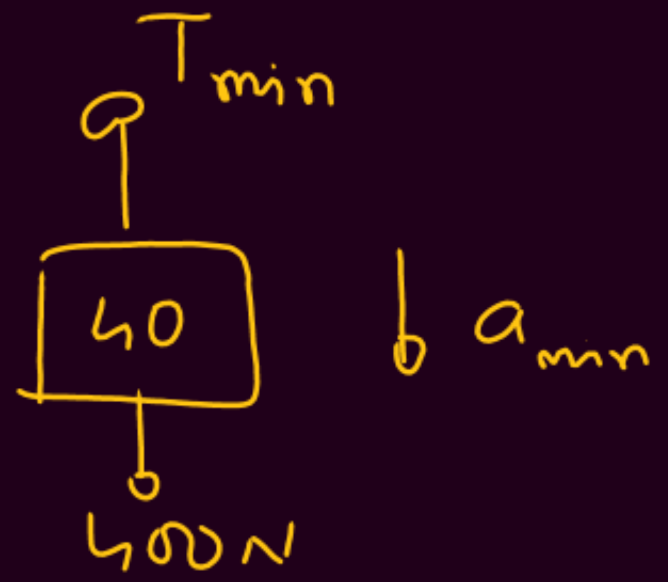
$$600 - 400 = 40a$$

$$200 = 40a$$

$$a = 5\ m/s^2$$

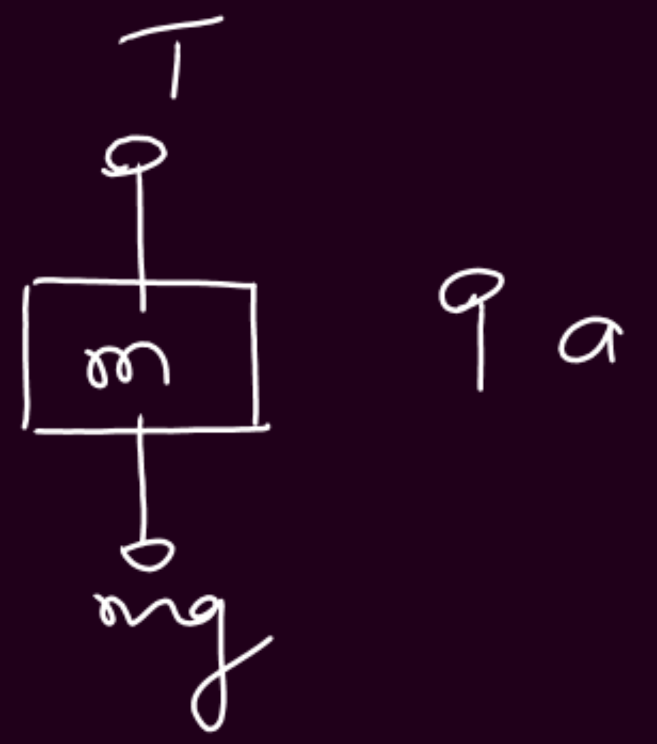
Q Rope — 300 N

$m = 40\,kg$



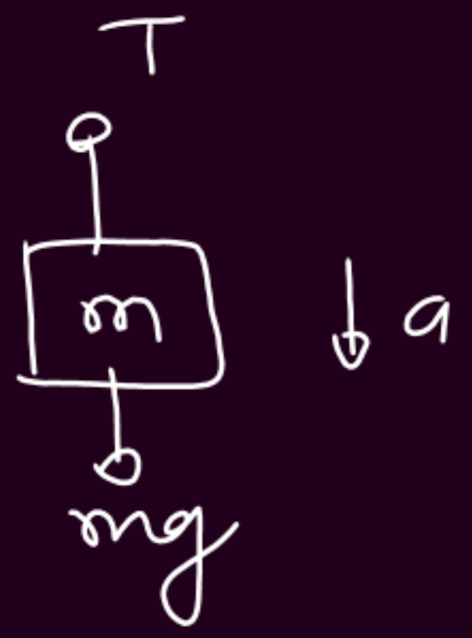
$$400 - 300 = 40a$$

$$a = \frac{100}{40} = 2.5\ m/s^2$$



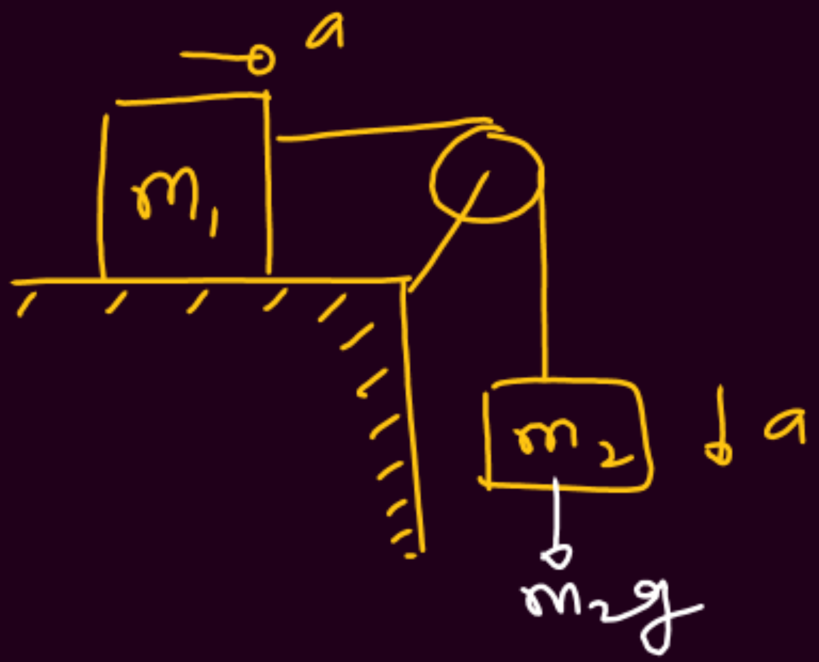
$$T - mg = ma$$

$$\boxed{T = m(g+a)}$$



$$mg - T = ma$$

$$\boxed{T = m(g-a)}$$

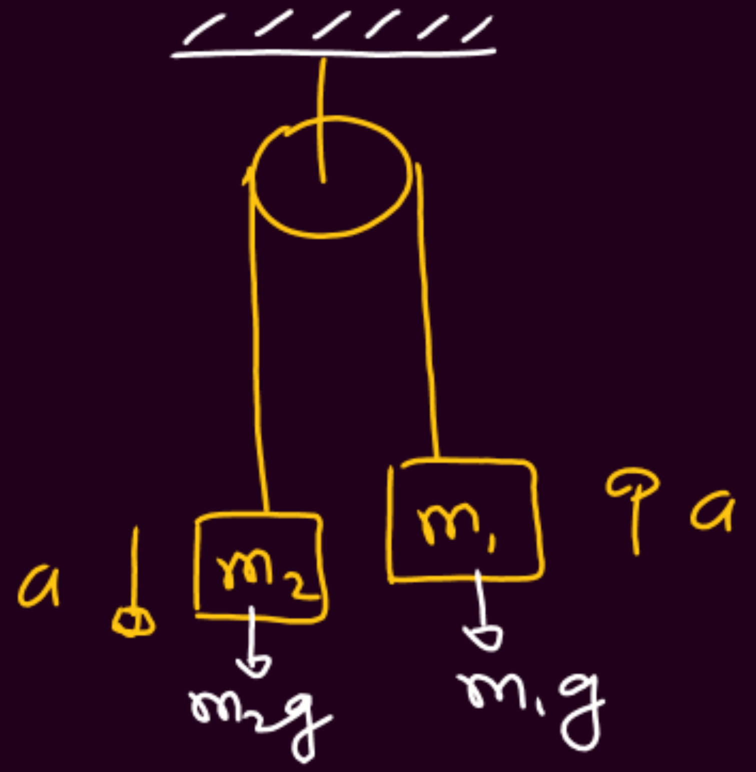


① $a = \dfrac{m_2 g}{m_1 + m_2}$

② $T = \dfrac{m_1 m_2 g}{m_1 + m}$

$T = m_1 a$

$T = m_2(g - a)$



① $a = \dfrac{(m_2 - m_1) g}{m_2 + m_1}$

② $T = \dfrac{2 m_1 m_2 g}{m_1 + m_2}$

$T = m_2 (g - a)$

$T = m_1 (g + a)$

Q

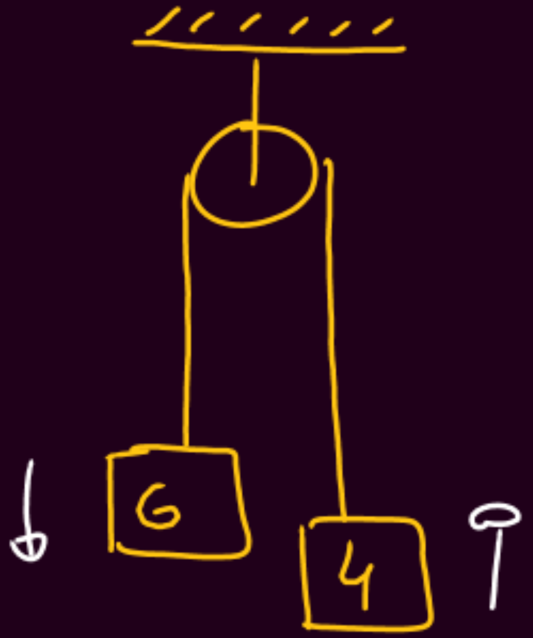
$$a = \frac{4g}{6+4}$$

$$a = 4\,m/s^2$$

$$T = 4(g-4)$$

$$T = 24N$$

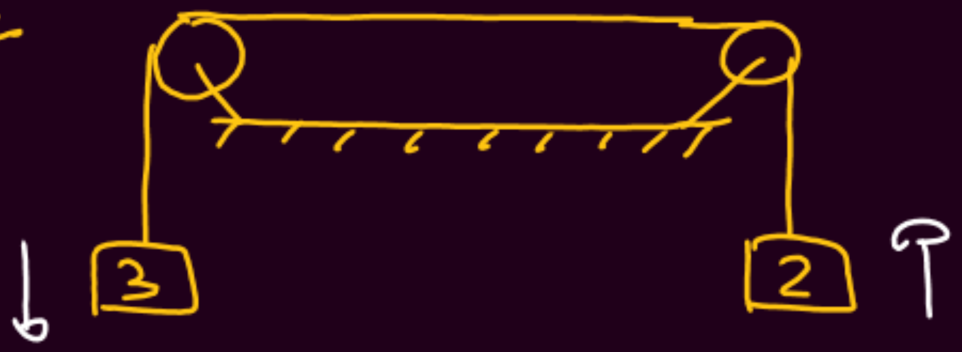
Q



$$a = \frac{(6-4)g}{6+4} = 2\,m/s^2$$

$$T = 4(g+2) = 48N$$

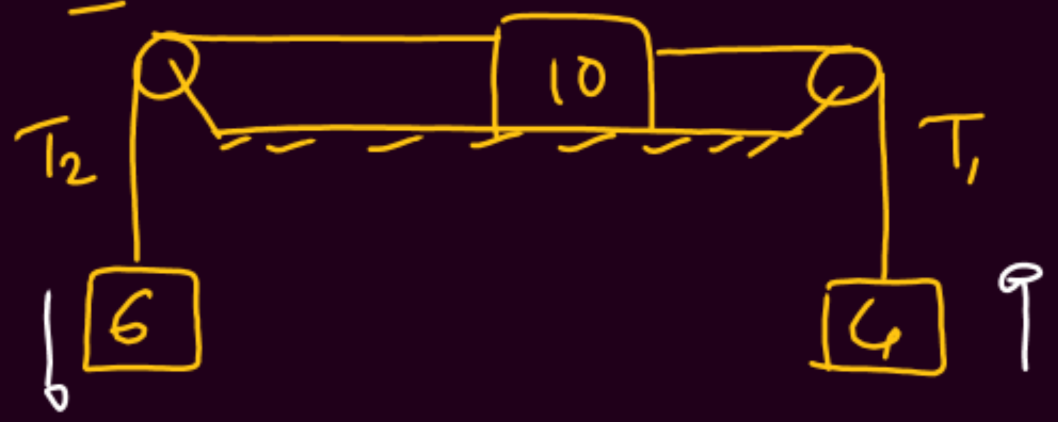
Q:



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

$$T = 2(g+2) = 24N$$

Q.

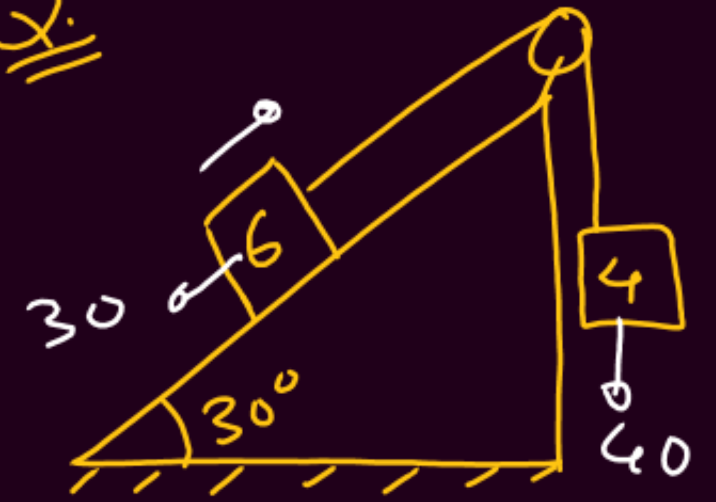


$$a = \frac{(6-4)g}{6+10+4} = 1\,m/s^2$$

$$T_1 = 4(g+1) = 44\,N$$

$$T_2 = 6(g-1) = 54\,N$$

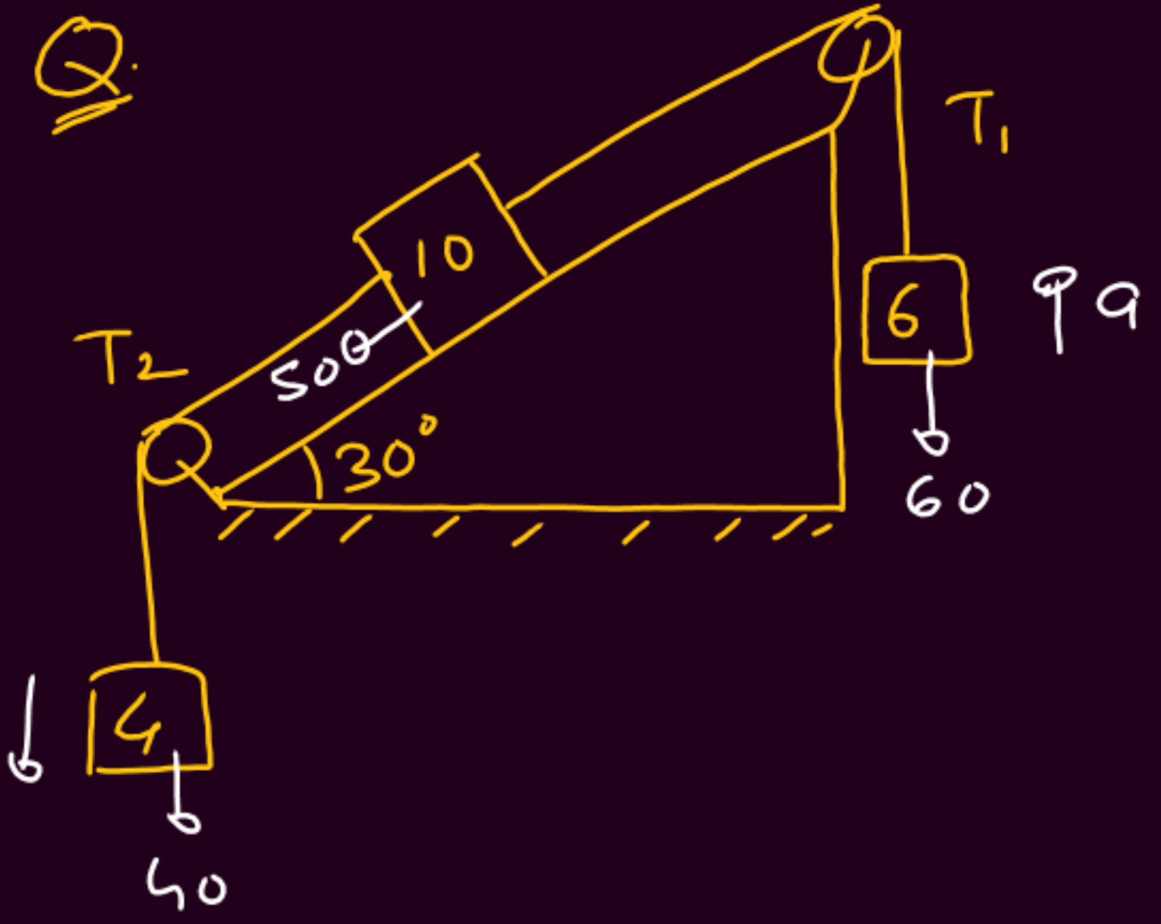
Q.



$$a = \frac{40-30}{6+4} = 1\,m/s^2$$

$$T = 4(g-1) = 36\,N$$

Q.



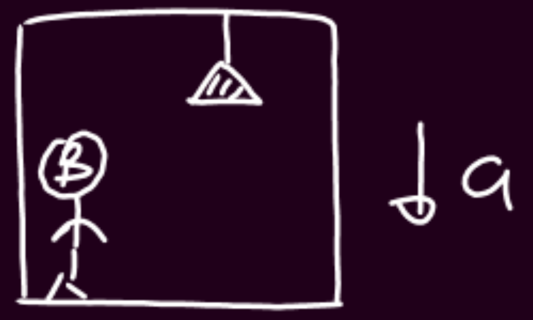
$$a = \frac{40+50-60}{4+10+6} = 3/2\ m/s^2$$

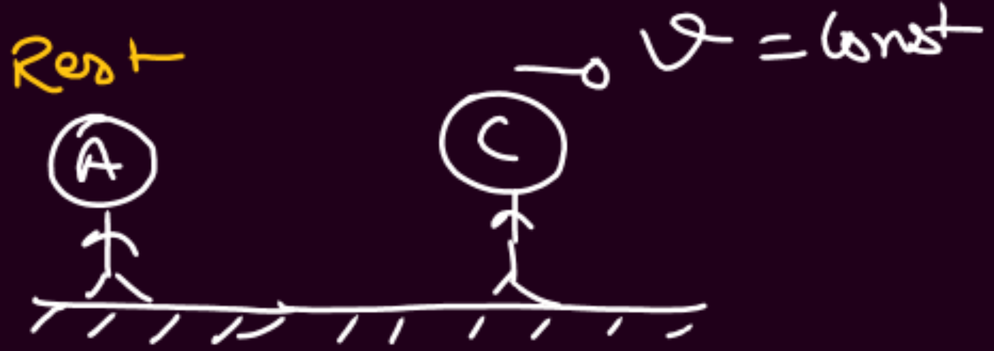
$$T_1 = 6(g+1.5) = 69\,N$$

$$T_2 = 4(g-1.5) = 34\,N$$

Inertial & Non-inertial frames

→ Ideal Concept





$T = m(g-a)$

$T = mg$

→ Ground

Pseudo Force

→ Not Real

→ Non-inertial

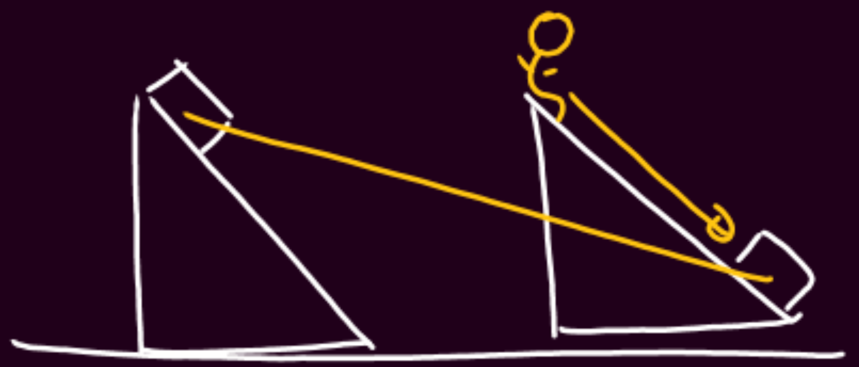
$$\boxed{F = -m_o a_f}$$

m_o = mass of object

a_f = acc. of frame

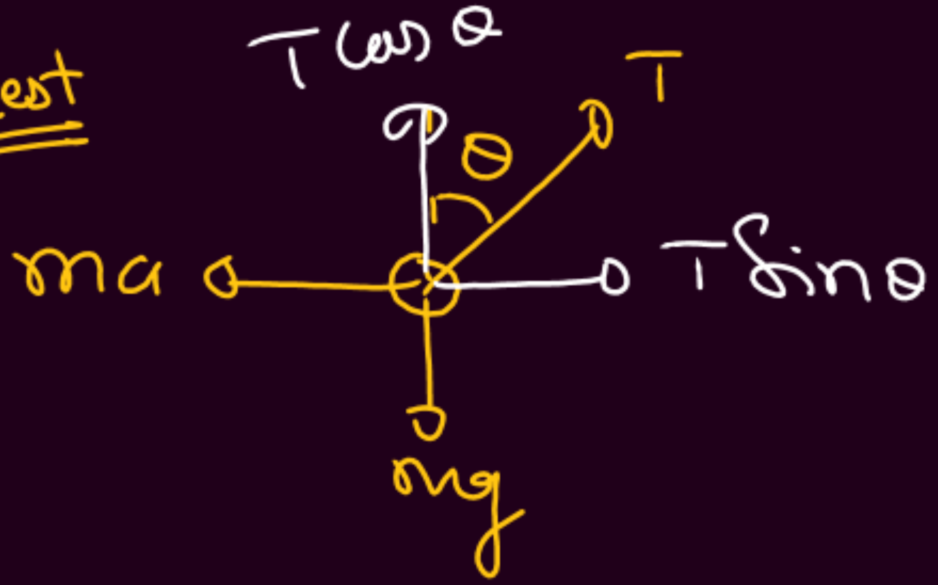
$T + ma = mg$

$T = m(g-a)$



Car frame

Rest

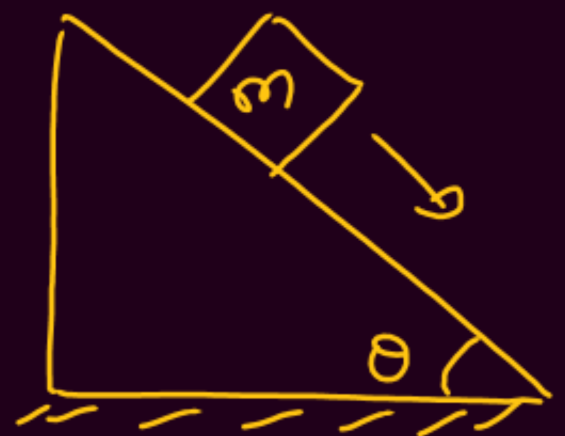


① $T\sin\theta = ma$

② $T\cos\theta = mg$

③ $$\boxed{\tan\theta = \frac{a}{g}}$$

④ $T = m\sqrt{g^2 + a^2}$



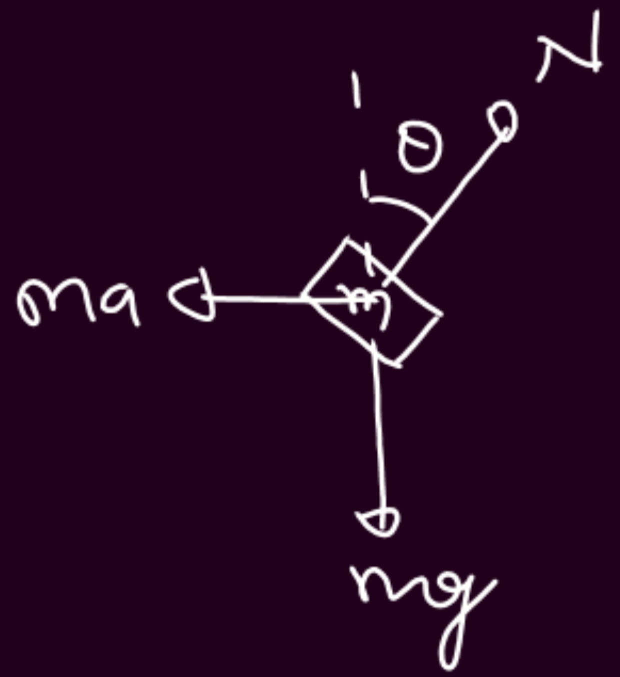
fixed wedge

$$N = mg\cos\theta$$

a = ?
such that Block doesn't slide on wedge

① $a = g\tan\theta$

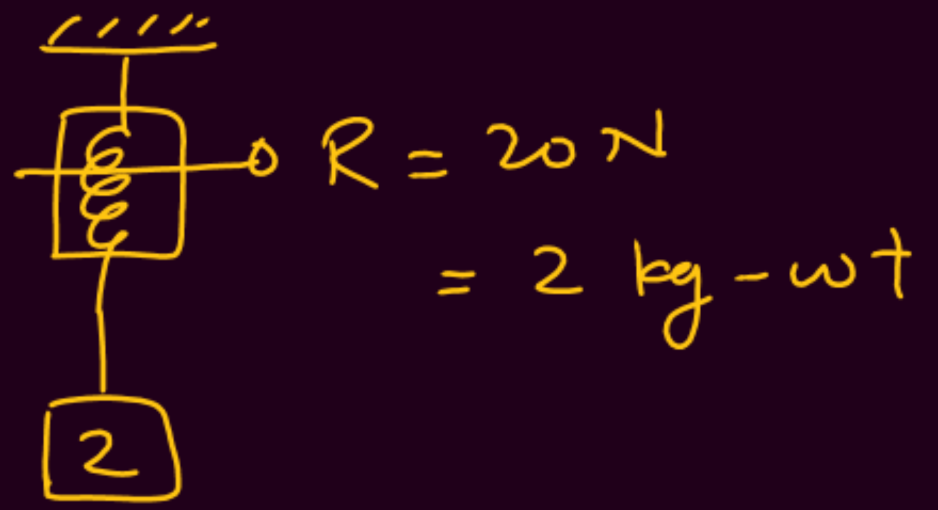
② $N = \dfrac{mg}{\cos\theta}$

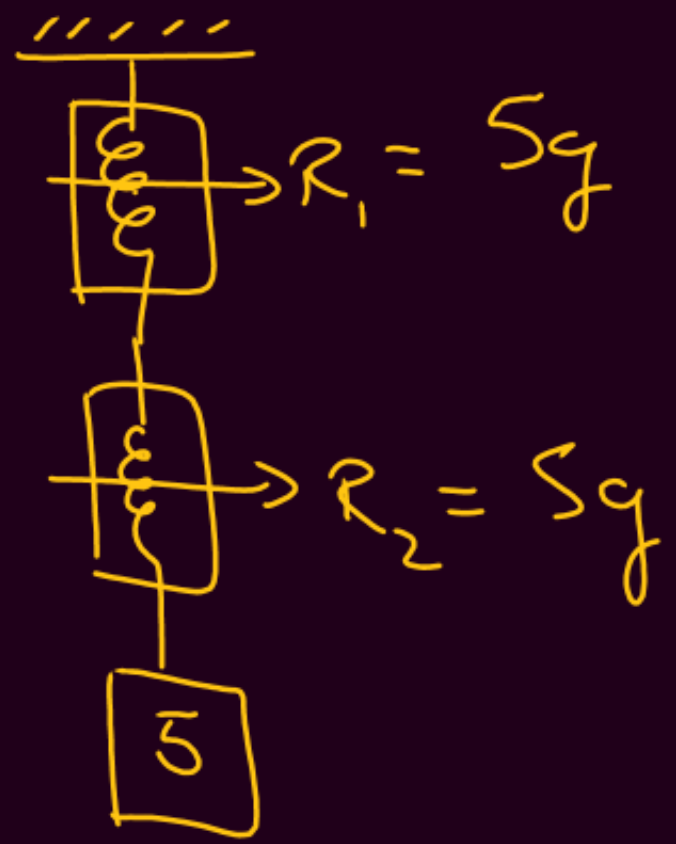


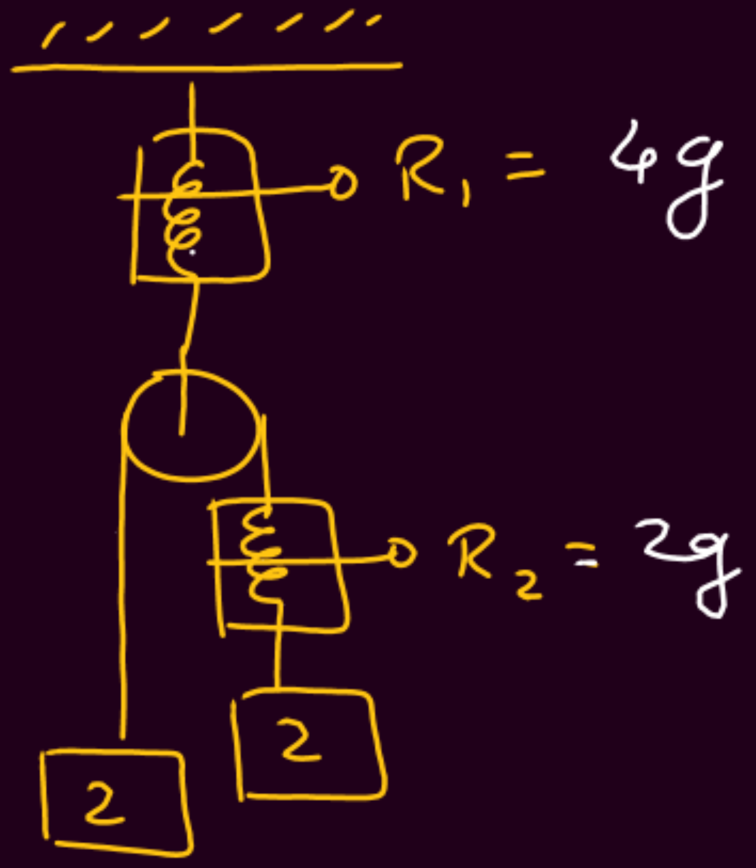
Rest

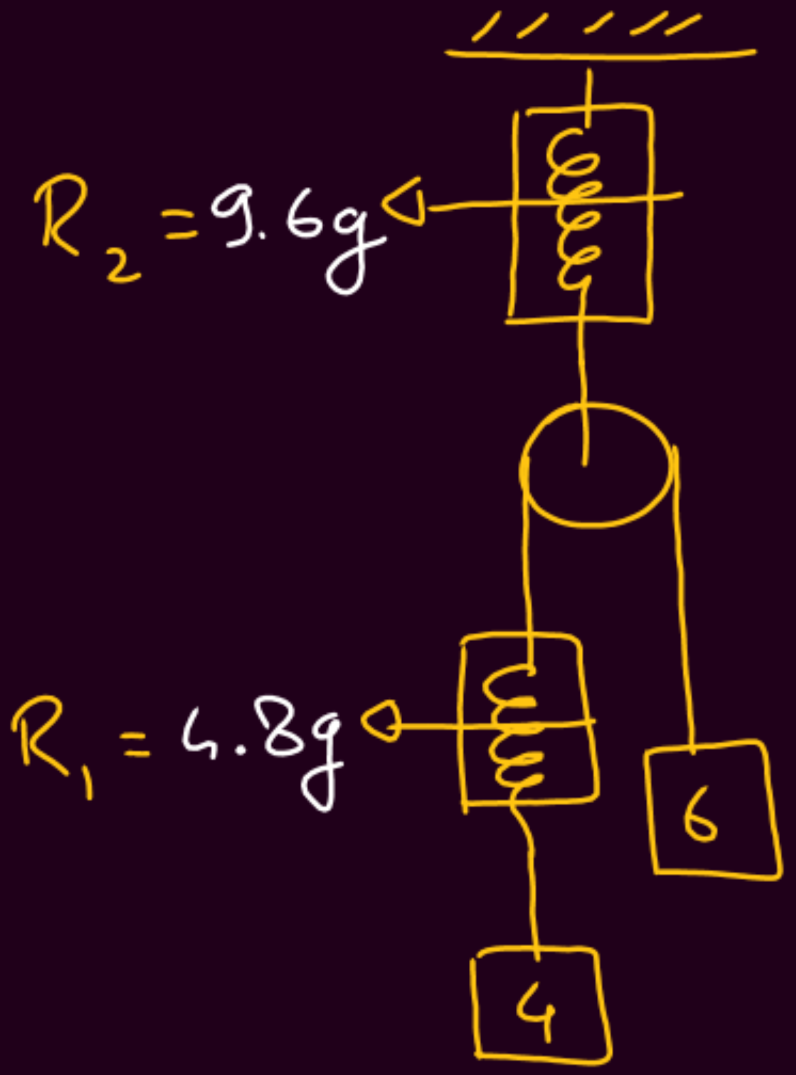
$$N\cos\theta = mg$$

Spring Balance (Tension)

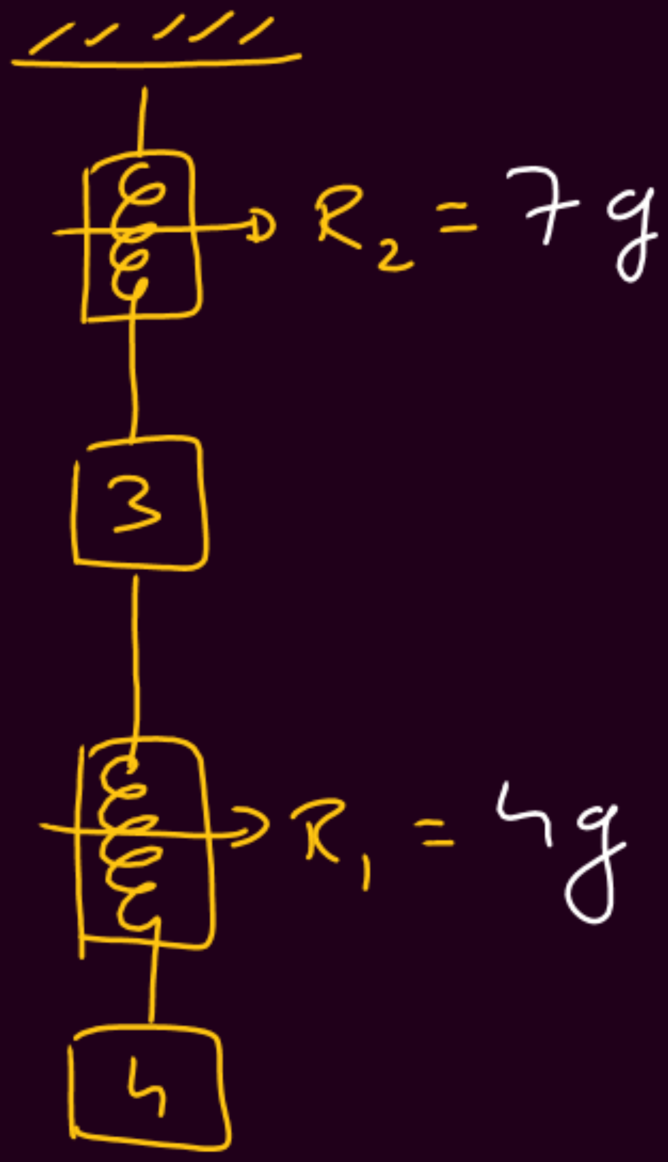


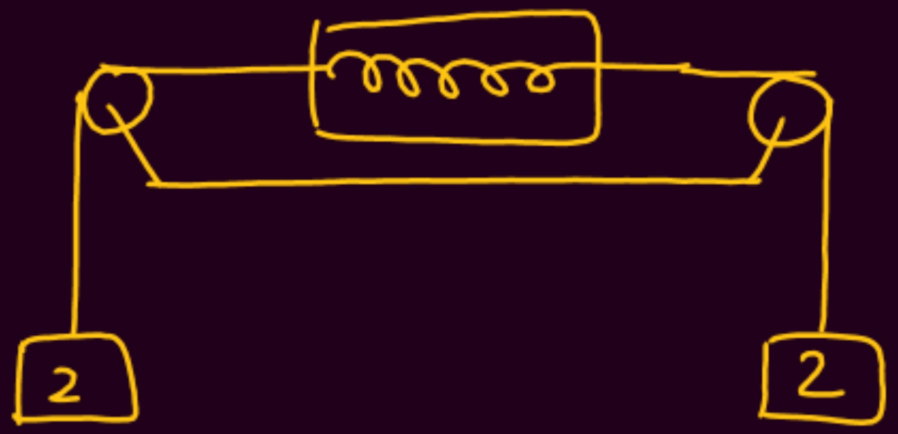






$$R_1 = \frac{2(4)(6)g}{4+6} = 4.8g$$





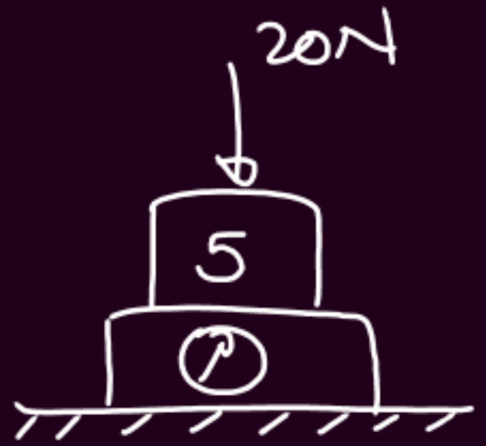
$R = 2g$

$R = 100N$

$R = 100N$

Weighing Machine (N) = App Weight

$R = 5g$



$R = 50 + 20$

$= 70\,N$

$R = 50 - 30$

$= 20\,N$

Lift

Rest / Const vel

$R = mg$

$a \uparrow$

$R = m(g+a)$

$a \downarrow$ $(a<g)$

$R = m(g-a)$

$a = g \downarrow$

Satellite / free fall

weightlessness

$R = 0$

Q Rest R = 80 kg

a = 2 ? R = ?

$R = m(g+a)$

$= 80(10+2)$

$= 960\ N$

Q.

$m(g+a) = 90g$

$m(g-a) = 60g$

Add

$2mg = 150g$

$\boxed{m = 75\ kg}$

$75(g+a) = 90g$

$a = 2\ m/s^2$

Bird Cage

① Wired Cage

m_1 = Bird

m_2 = Cage

① Bird at Rest

$$R = (m_1 + m_2)g$$

② Bird is flying

$$R < (m_1 + m_2)g$$

② Air Tight Cage

① Rest / Const. vel

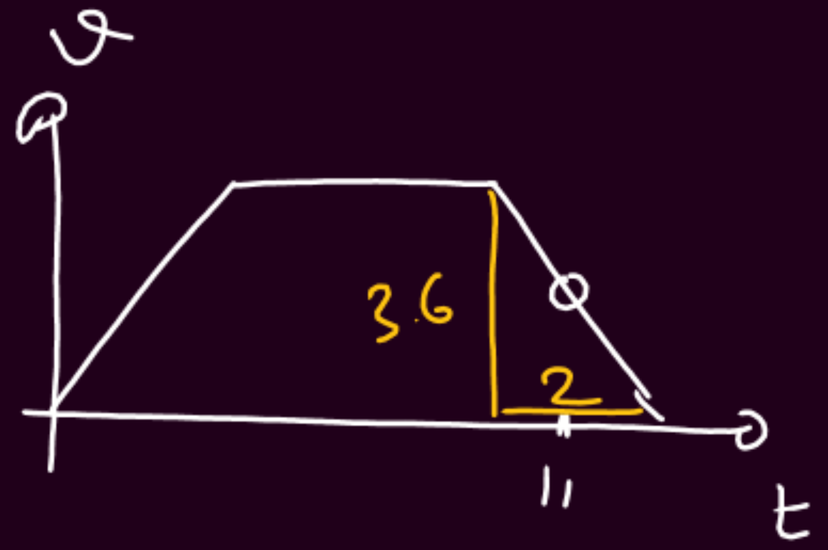
$$R = (m_1 + m_2)g$$

② $\uparrow a$ Bird

$$R = m_1(g + a) + m_2 g$$

Pg-127

4



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

$$R = 1500\left(9.8 - \frac{3.6}{2}\right)$$

$$\underline{R = 12000 \text{ N}}$$

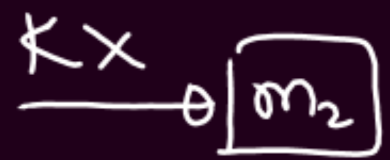
Pg-162

28

$$F - kx = m_1 a_1$$

$$F - m_2 a_2 = m_1 a_1$$

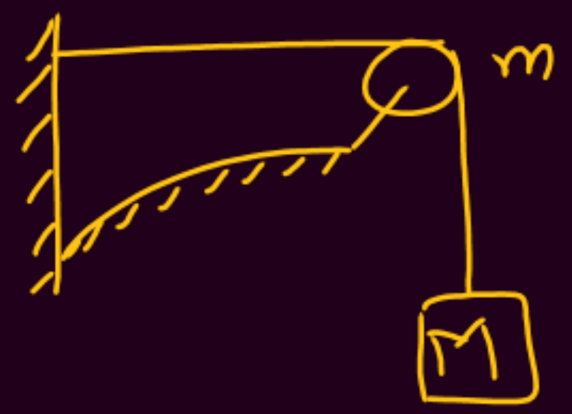
$$F - m_1 a_1 = m_2 a_2$$



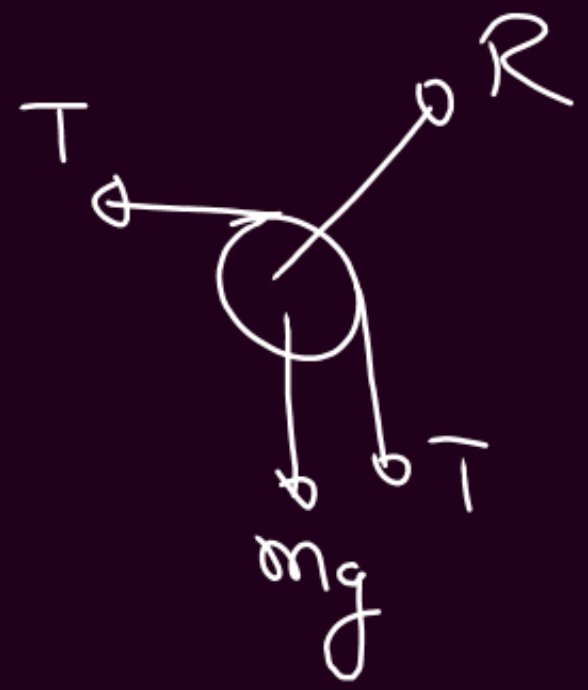
$$kx = m_2 a_2$$

Pg-133

(9)



Pulley



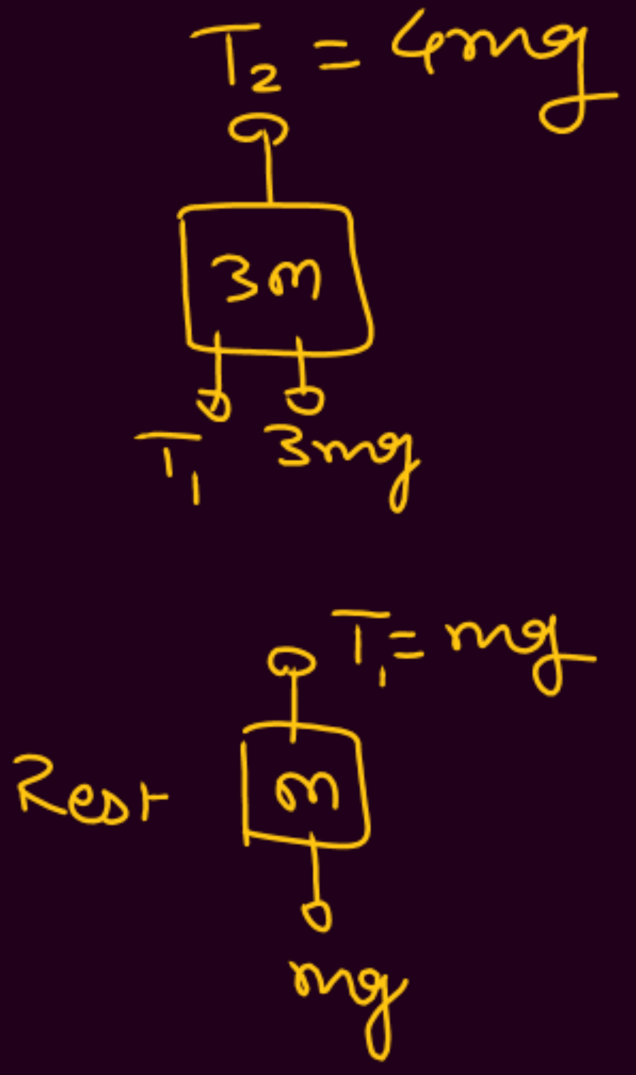
$$R = \sqrt{(mg + T)^2 + T^2}$$

$$R = \sqrt{(mg + Mg)^2 + (Mg)^2}$$

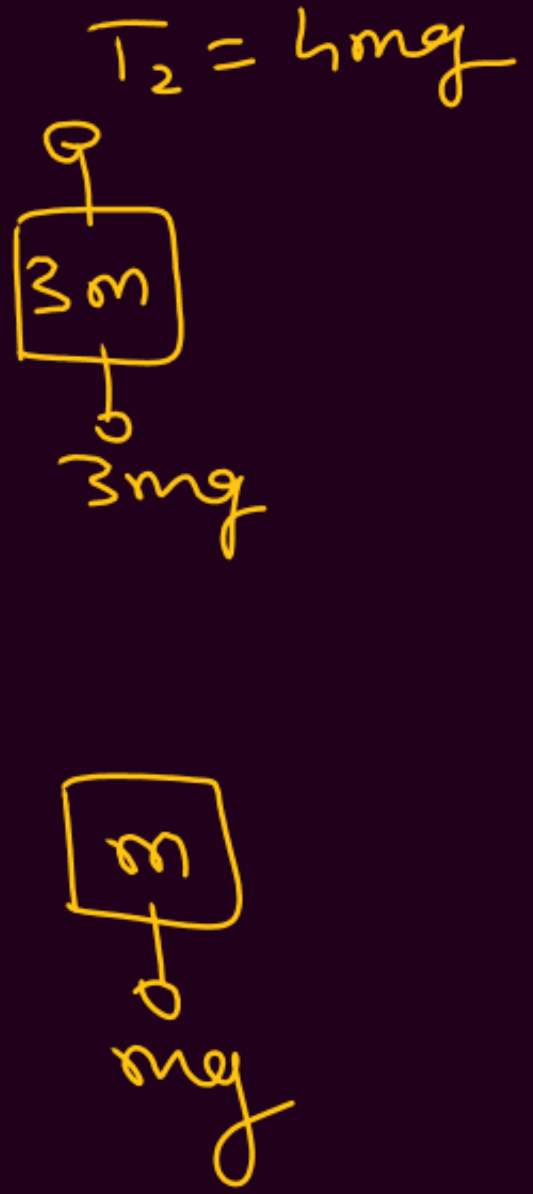
Pg-173

22

Just Before



Just After

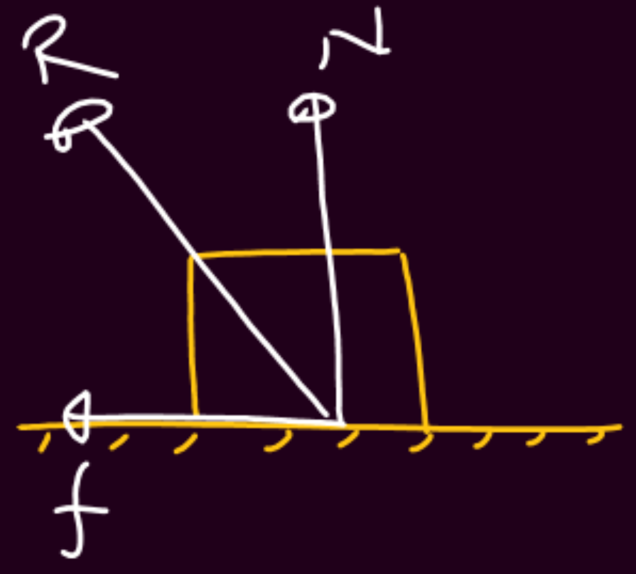


$$\uparrow a = \frac{4mg - 3mg}{3m} = g/3$$

$$\downarrow a = \frac{mg}{m} = g\downarrow$$

Friction

→ opposses the relative motion betⁿ surfaces

→ 

$$R = \sqrt{N^2 + f^2}$$

→ Static → no rel. motion betⁿ surfaces

→ Kinetic (Sliding) → rel. motion

Macroscopic View → Roughness

Microscopic View → Actual pts. in contact

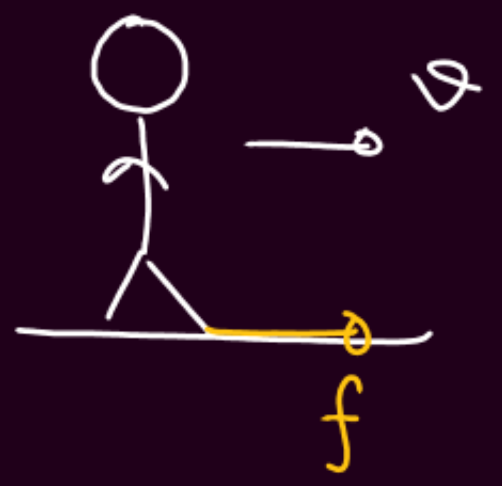
① Smooth $f \downarrow$

② Very smooth $f \uparrow\uparrow$ (Cold Welding)

Static friction (f_s)

- walking / Running
- 

→ Self Adjusting



Limiting Friction $\boxed{f_L = \mu_s N}$

(max f_s)

μ_s = coeff of static friction

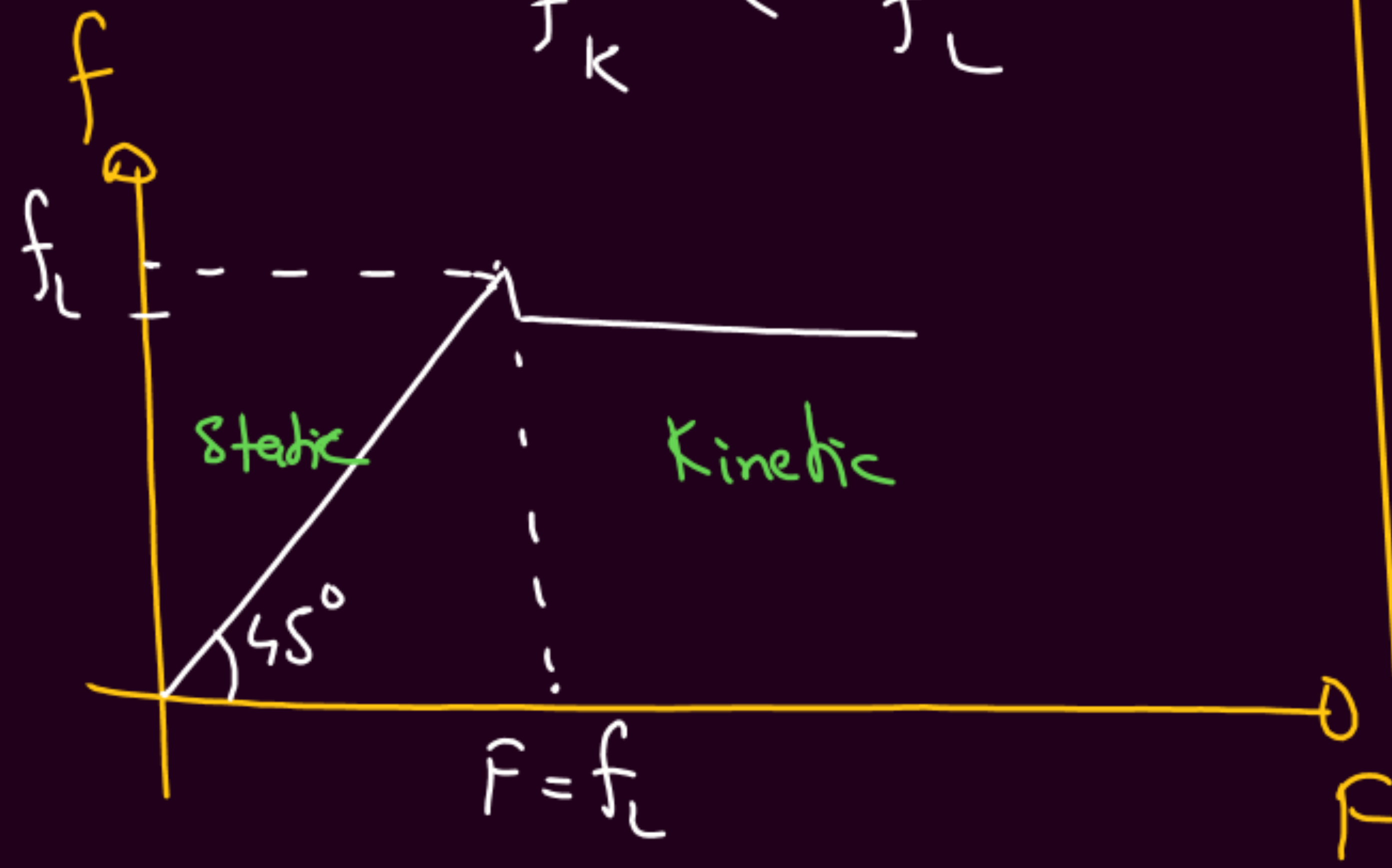
Kinetic (f_k)

$$\boxed{f_k = \mu_k N}$$

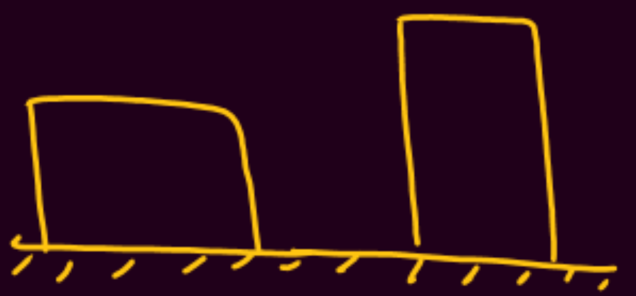
μ_k = coeff of kinetic friction

$\mu_k < \mu_s$

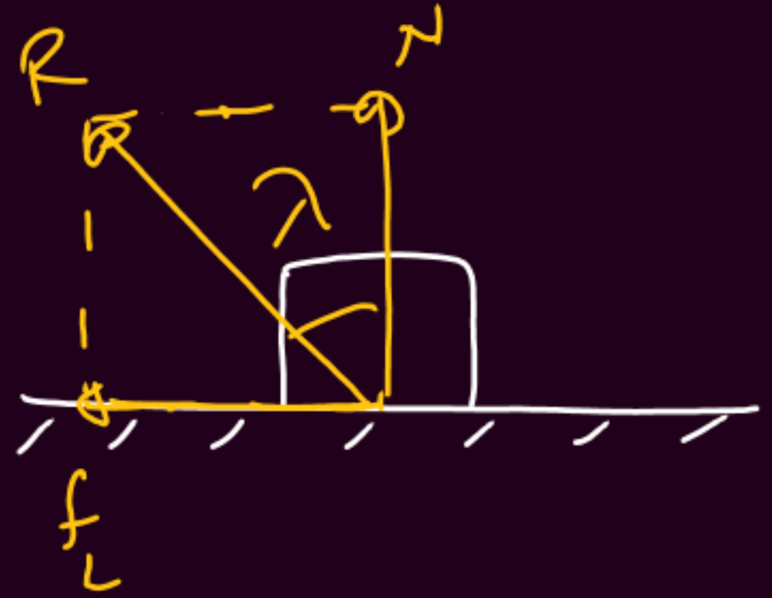
$f_k < f_L$



f_k / f_L is independent of Surface Area



Angle of Friction



$$\tan\lambda = \frac{f_L}{N} = \frac{\mu_s N}{N}$$

$$\boxed{\tan\lambda = \mu_s}$$

$\mu_k = 0.4$

$\mu_s = 0.5$

① $N = 50N$

② $f_k = 0.4(50) = 20N$

③ $f_L = 0.5(50) = 25N$

① $F = 10N$	Rest	$f_s = 10N$
② $F = 22N$	Rest	$f_s = 22N$
③ $F = 25N$	Rest	$f_L = 25N$
④ $F = 26N$	$a = \frac{26-20}{5}$	$f_k = 20N$
⑤ $F = 30N$	$a = \frac{30-20}{5}$	$f_k = 20N$

Q.

$\mu_s = 0.4$

$\mu_k = 0.35$

$N = 100N$

$f_L = 40N$

$f_k = 35N$

$a = ?$

$$a = \frac{50 - 35}{10} = 1.5\ m/s^2$$

Q.

$\mu = 0.5$

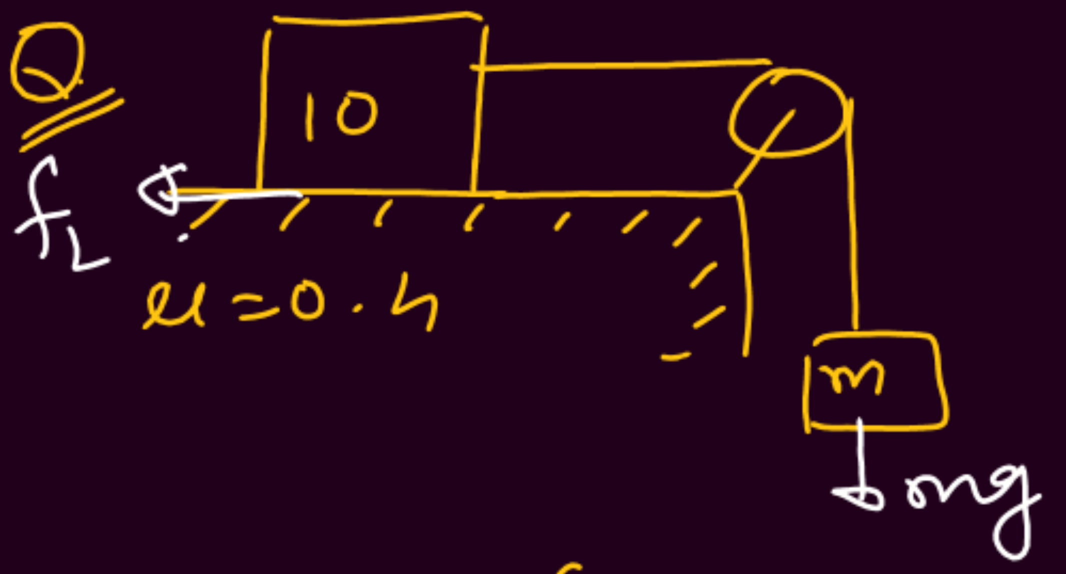
Distance before Rest?

$$a = \frac{f_k}{m} = \frac{\mu mg}{m}$$

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

$$\boxed{S = \frac{u^2}{2(\mu g)}} = \frac{(10)^2}{2 \times 0.5 \times 10} = 10m$$

Q



max m for Rest ?

$N = 100\,N$

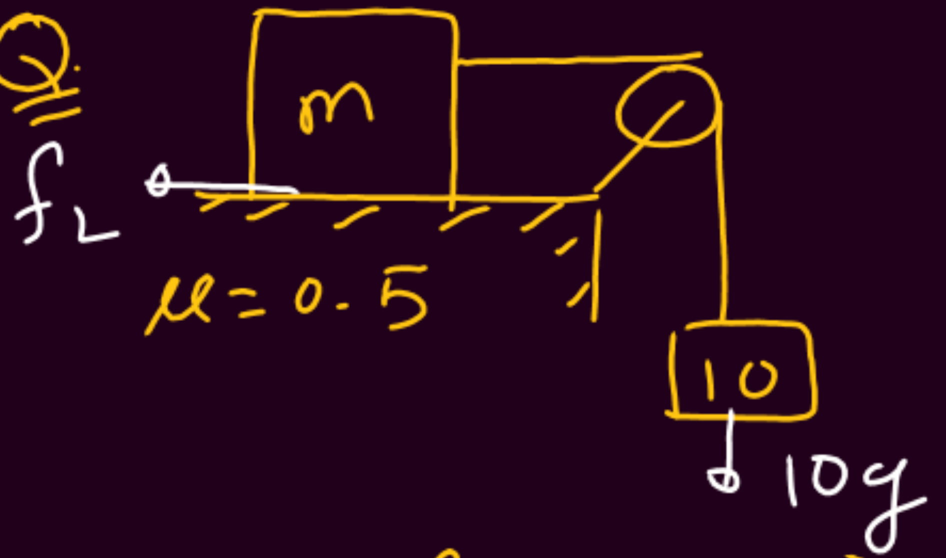
$f_L = 0.4(100) = 40\,N$

$mg = f_L$

$m(10) = (40)$

$\boxed{m = 4\,kg}$

Q



min m for rest ?

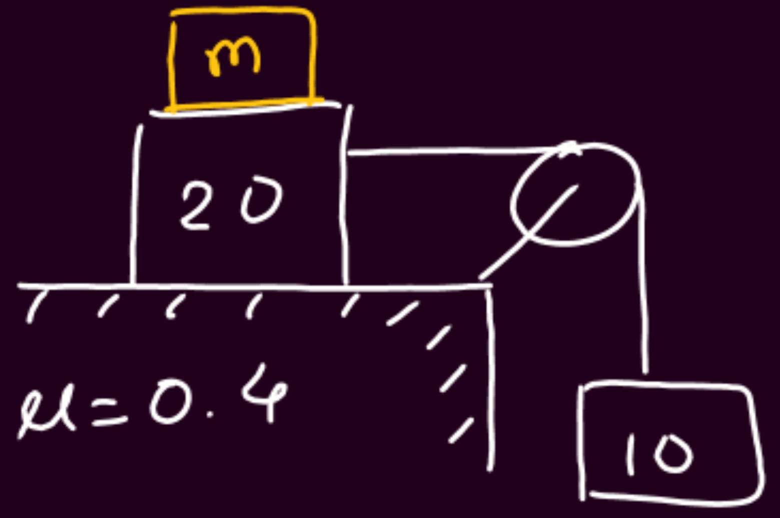
$N = mg$

$f_L = 0.5mg$

$0.5mg = 10g$

$m = 20\,kg$

Q



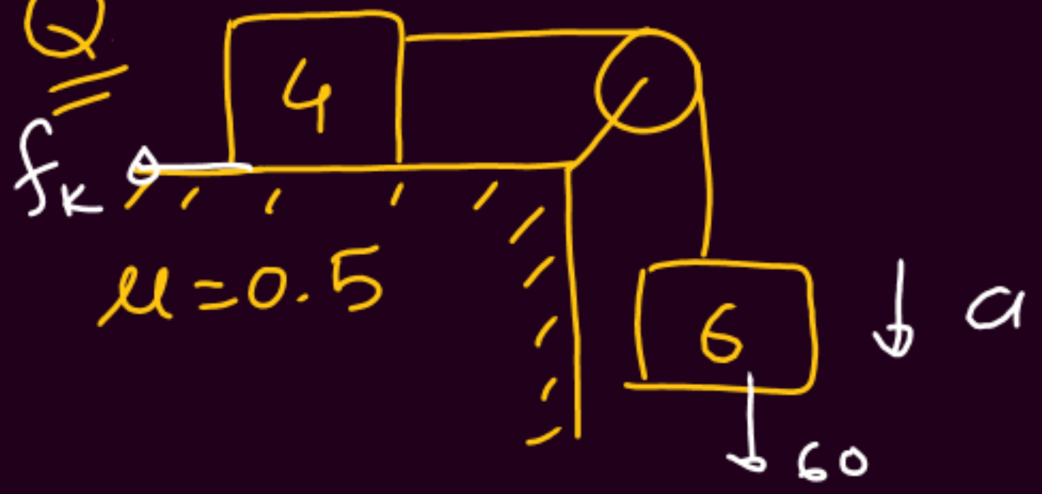
min m for Rest ?

$f_L = 0.4(m+20)g = 10g$

$(m+20) = \frac{10}{0.4} = 25$

$m = 5\,kg$

Q

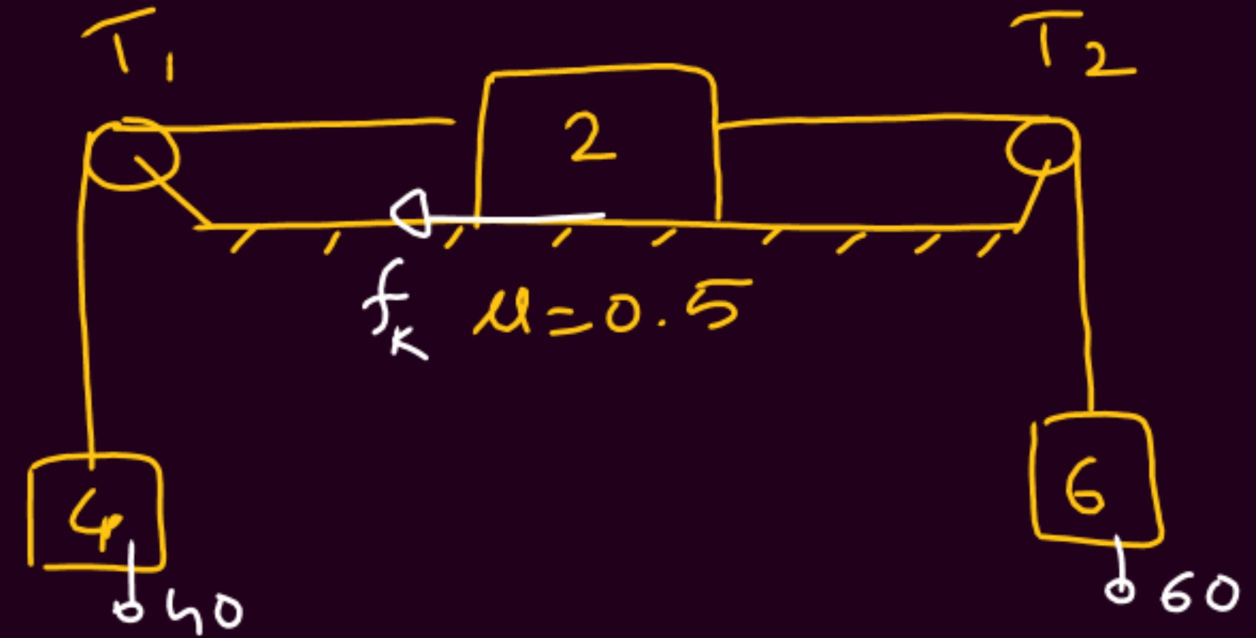


① $f_L = 0.5\,(4g) = 20\text{ N}$

② $a = \dfrac{60-20}{6+4} = 4\text{ m/s}^2$

③ $T = 6(g-4) = 36\text{ N}$

Q.



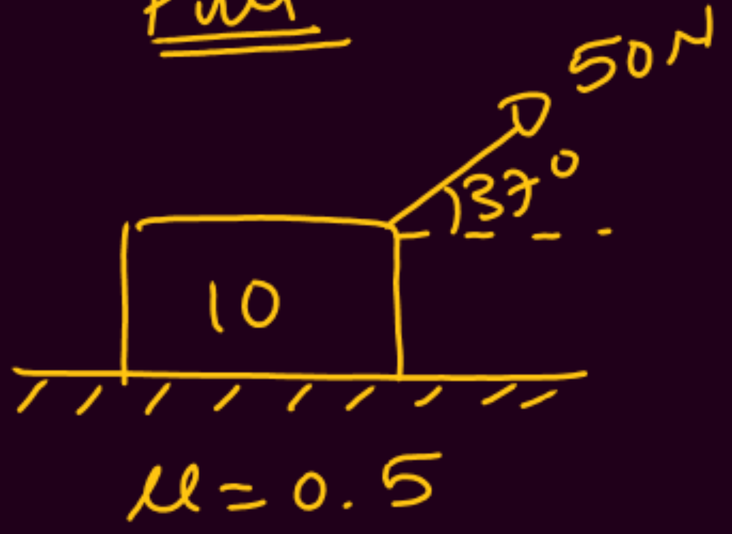
① $f_L = 0.5\,(20) = \underline{10\text{ N}}$

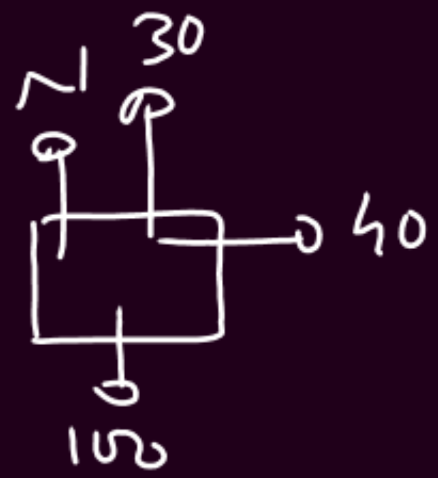
② $a = \dfrac{60-40-10}{6+4+2} = 5/6\text{ m/s}^2$

③ $T_1 = 4\left(g + 5/6\right)$

④ $T_2 = 6\left(g - 5/6\right)$

Pull



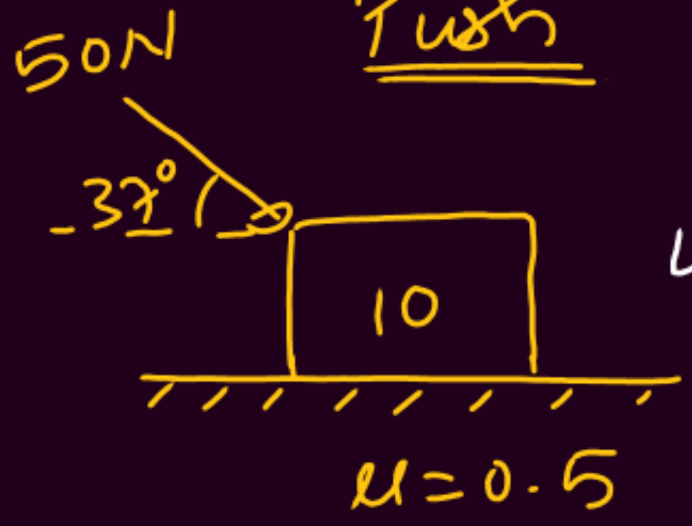


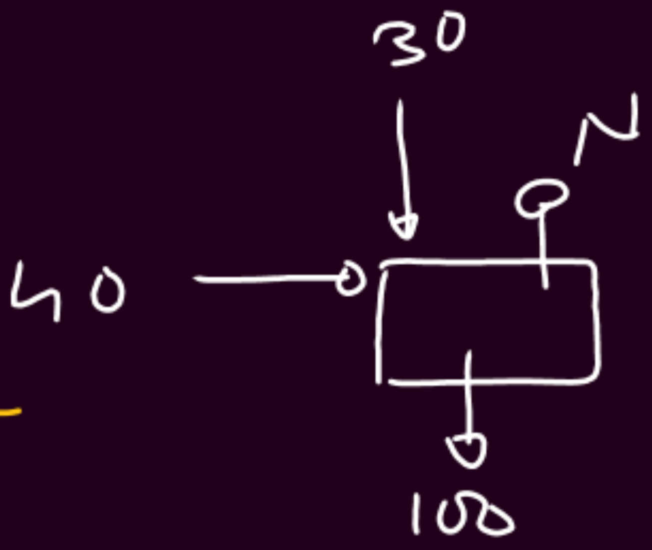
① $N = 100 - 30 = 70\,N$

② $f_L = 0.5(70) = 35\,N$

③ $a = \dfrac{40 - 35}{10} = 0.5\,m/s^2$

Push





① $N = 100 + 30 = 130\,N$

② $f_L = 0.5(130) = 65\,N$

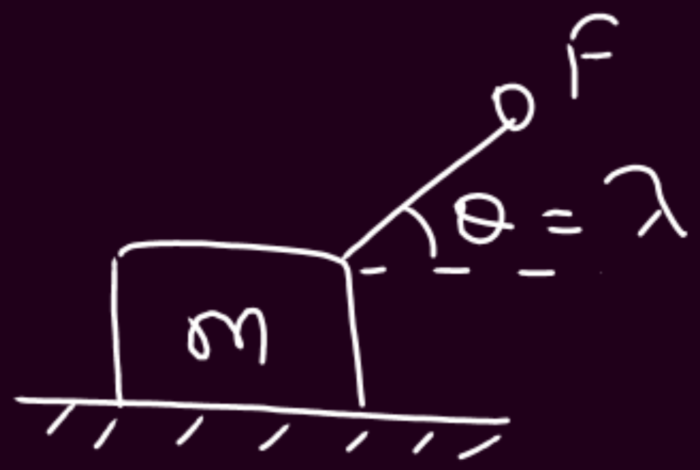
③ $a = 0$ (Rest)

④ $\boxed{f_s = 40N}$

①

$$\boxed{F = \mu mg}$$

②



$$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$$

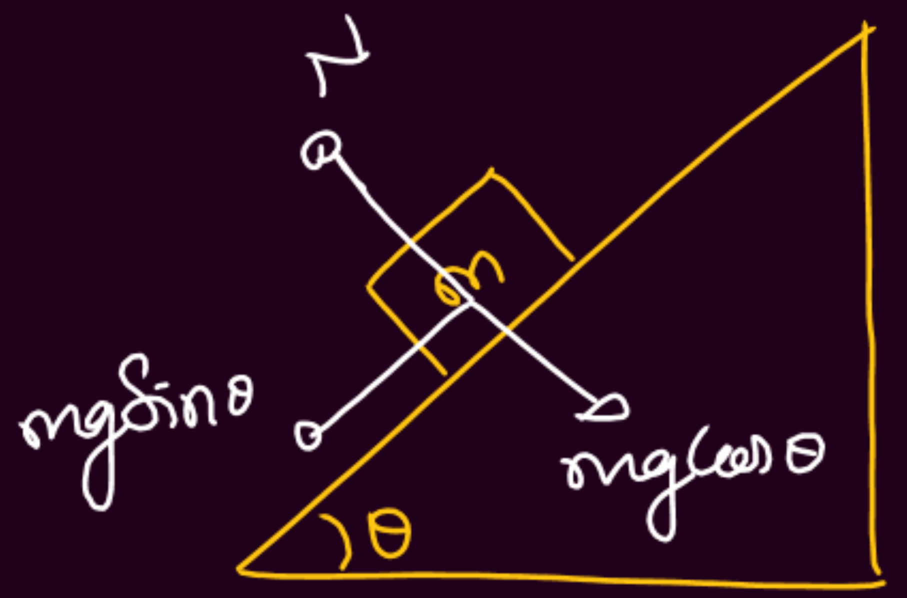
Q.

$\mu = 0.5$

① Min Horizontal $F = 0.5(100) = 50N$

② Min force $F = \dfrac{0.5(100)}{\sqrt{1+(0.5)^2}} \approx \dfrac{50}{1.1}$

Friction on Inclined Plane



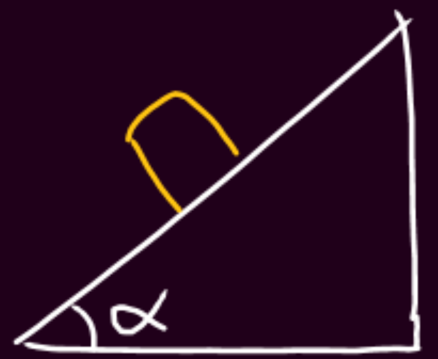
① $N = mg\cos\theta$

② $f_L = \mu mg\cos\theta$

if ① $mg\sin\theta \le f_L$ $\quad f_s = mg\sin\theta$

② $mg\sin\theta > f_L$ $\quad f_k = \mu mg\cos\theta$

Angle of Repose (α)



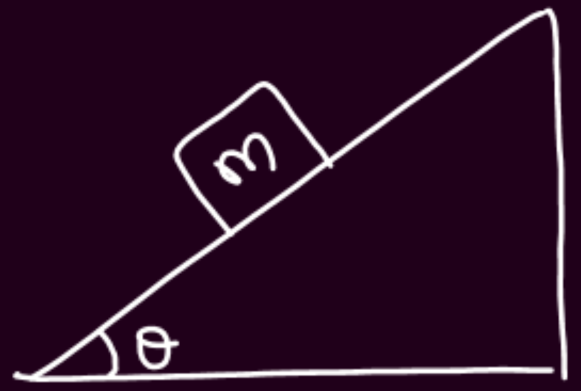
just

$$\boxed{\tan\alpha = \mu = \tan\lambda}$$

① $\tan\theta \le \mu$ Rest

② $\tan\theta > \mu$ Acc.

① $\tan\theta \le \mu$



① Rest

② $f_s = mg\sin\theta$

③ $R = mg$

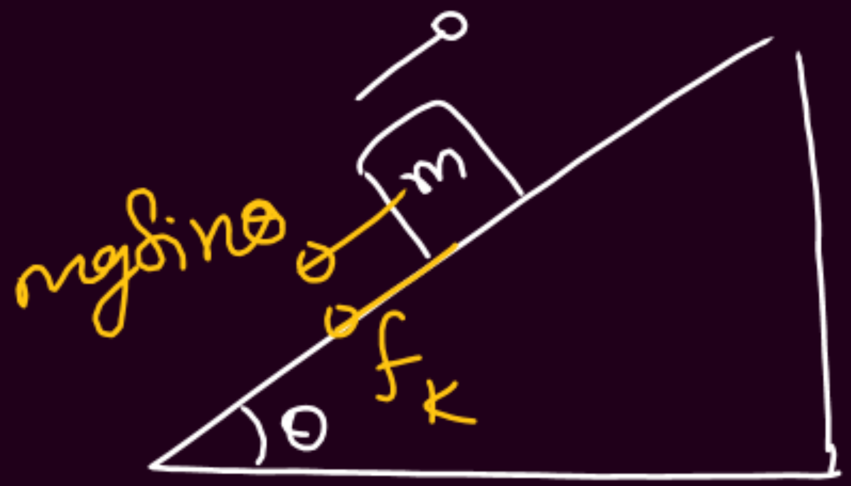
$$R = \sqrt{N^2 + f^2} = \sqrt{(mg\cos\theta)^2 + (mg\sin\theta)^2}$$

② $\tan\theta > \mu$

$$a = \frac{mg\sin\theta - \mu mg\cos\theta}{m}$$

$$\boxed{a = g(\sin\theta - \mu\cos\theta)}$$

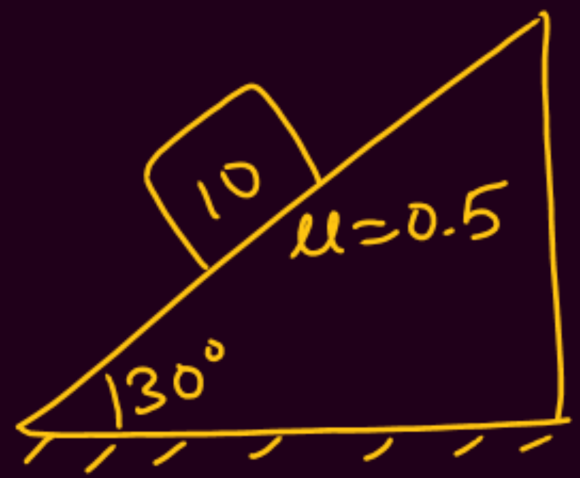
③ Projected Up



Retard

$$a = g(\sin\theta + \mu\cos\theta)$$

Q.



$\tan 30^\circ = \frac{1}{\sqrt{3}} = 0.577$

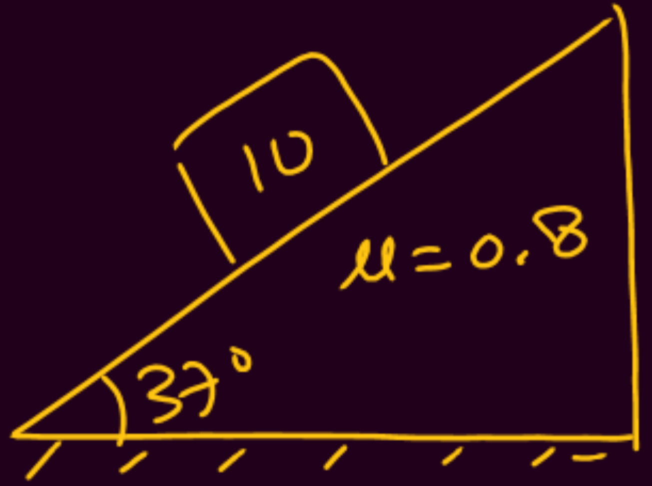
$\tan\theta > \mu$

$f_k = (0.5)(100\cos 30^\circ)$

$a = g(\sin 30^\circ - 0.5\cos 30^\circ)$

$\frac{1}{\sqrt{2}} = 0.707$

$\frac{1}{\sqrt{3}} = 0.577$

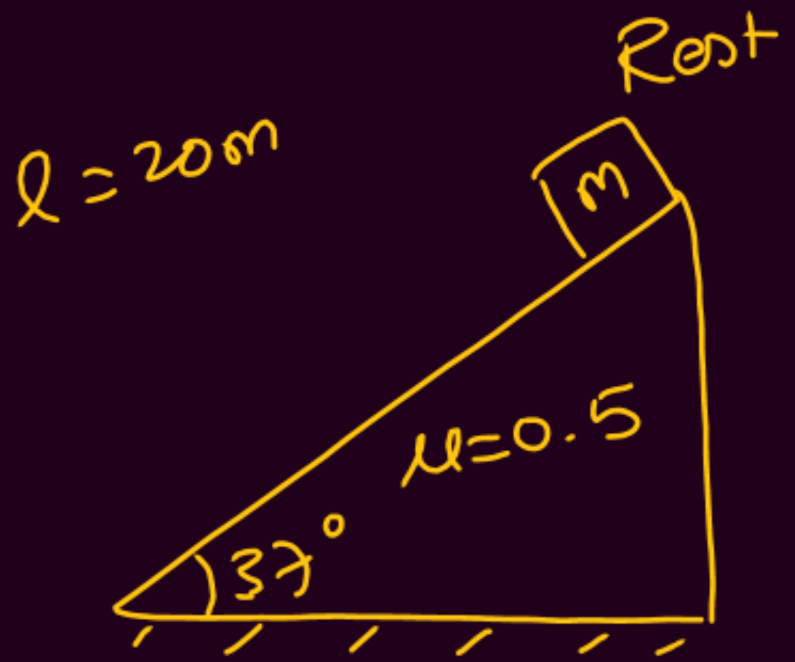


$\tan 37^\circ = \frac{3}{4} < \mu$

Rest

$f_s = 10g\sin 37^\circ = 60N$

$a = 0$



Bottom $v = ?$ $t = ?$

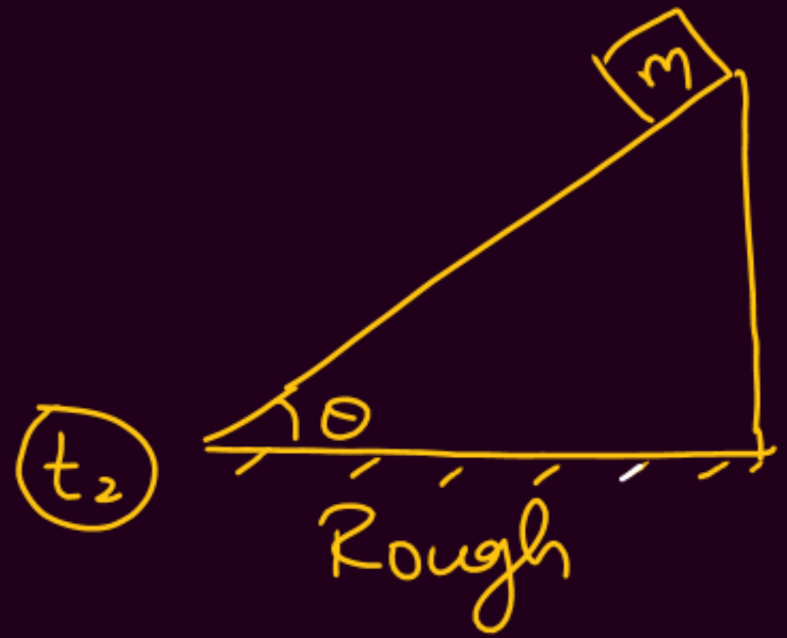
① $a = 10\left(\frac{3}{5} - 0.5\left(\frac{4}{5}\right)\right) = 2\,m/s^2$

② $v = \sqrt{2\times 2\times 20} = 4\sqrt{5}\,m/s$

③ $20 = \frac{1}{2}(2)t^2$

$t = 2\sqrt{5}\,s$

Case



$$\boxed{t_2 = n\, t_1}$$

then $$\boxed{\mu = \tan\theta\left(1 - \frac{1}{n^2}\right)}$$

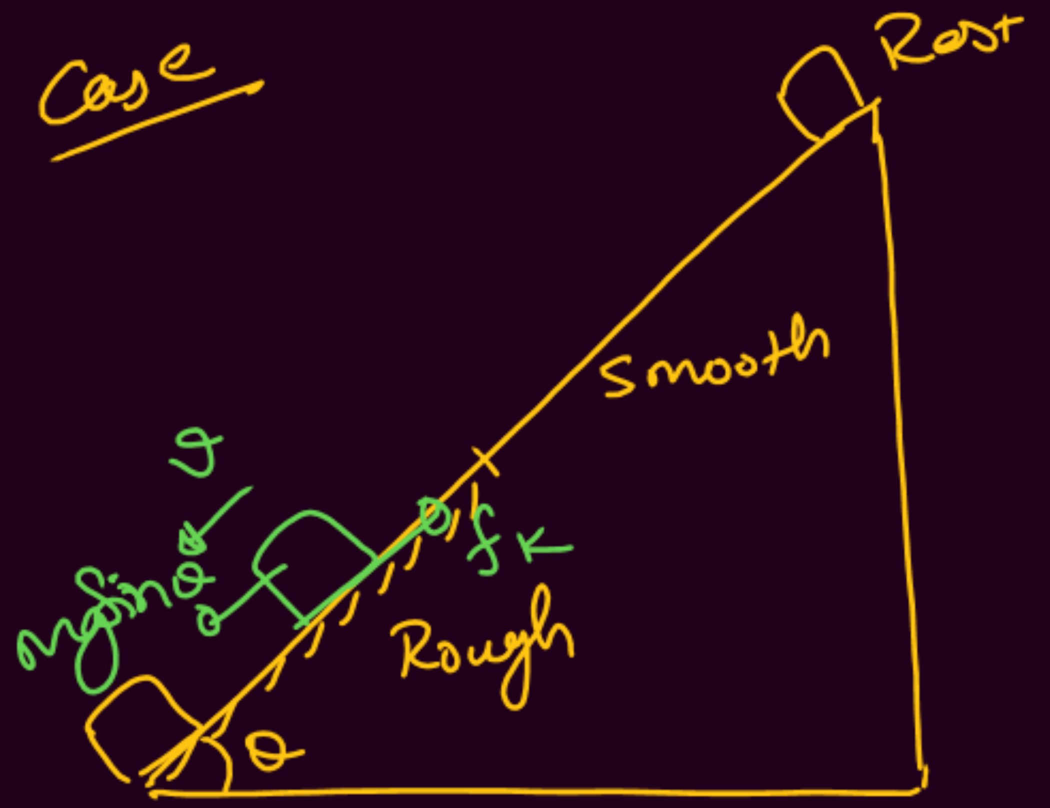
$$l_1 = l_2$$

$$\frac{1}{2} g\sin\theta \; t_1^2 = \frac{1}{2} g(\sin\theta - \mu\cos\theta) t_2^2$$

$$\sin\theta = (\sin\theta - \mu\cos\theta)\, n^2$$

$$\tan\theta = (\tan\theta - \mu)\, n^2$$

Case



Just reaches the Bottom

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

$$v^2 = 2a_1x_1 = 2a_2x_2$$

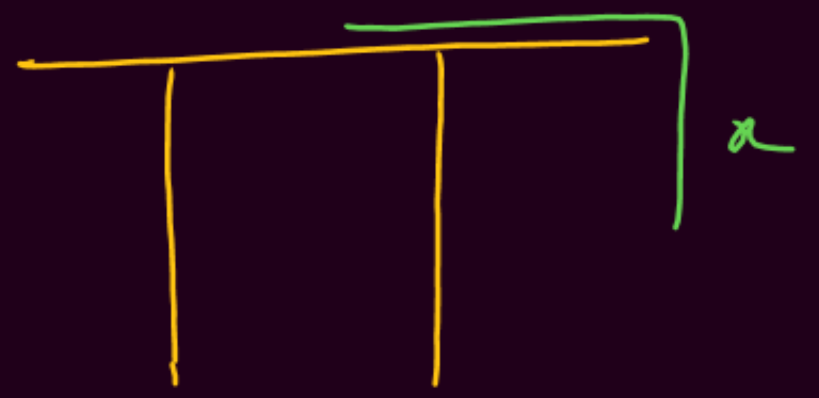
$$a_1 = a_2$$

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

$$\sin\theta = \mu\cos\theta - \sin\theta$$

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

Uniform Rope / chain



Max length that can be Hanged

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

$$\left(\frac{m}{l} x\right) g = \mu \frac{m}{l}(l - x) g$$

Q. $m = 4\,kg$

$l = 1\,m$

$\mu = 0.5$

$$x = \frac{0.5(1)}{1 + 0.5} = \frac{0.5}{1.5} = \frac{1}{3}\,m$$

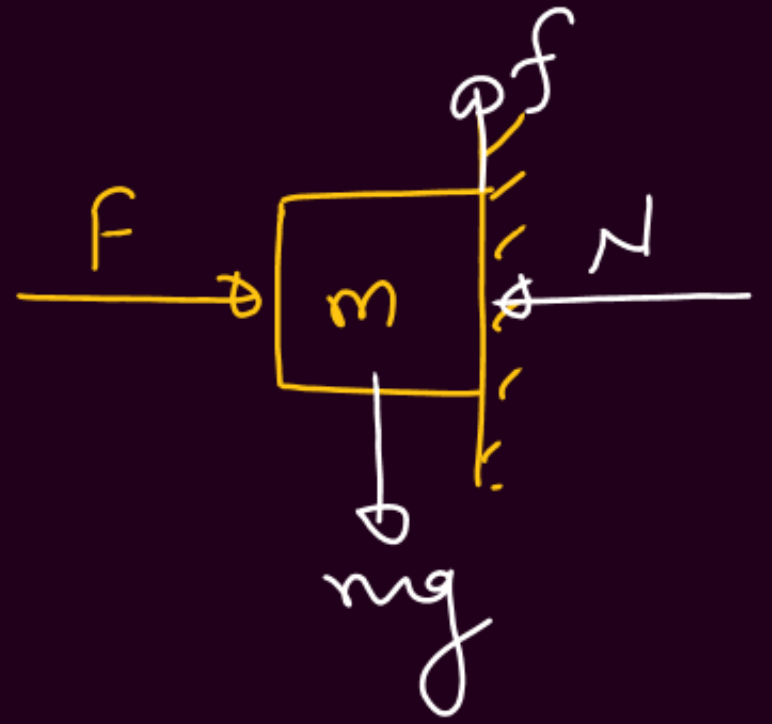
Q max 25%

$$l\left(\frac{25}{100}\right) = \frac{\mu l}{\mu + 1}$$

$$\mu + 1 = 4\mu$$

$$\boxed{\mu = 1/3}$$

Block Pressed against Wall



① $N = F$

② $f_L = \mu F$

Just $mg = \mu F$

$$\boxed{F = \frac{mg}{\mu}}$$

If

① $F \geq \frac{mg}{\mu}$

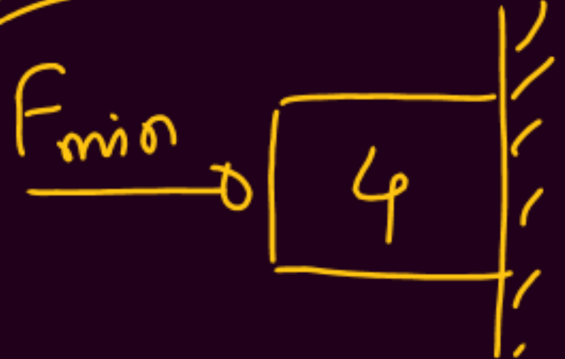
Rest $f_s = mg$

② $F < \frac{mg}{\mu}$

a $f_k = \mu F$

$$\boxed{\text{Rest } F \geq \frac{mg}{\mu}}$$

Q

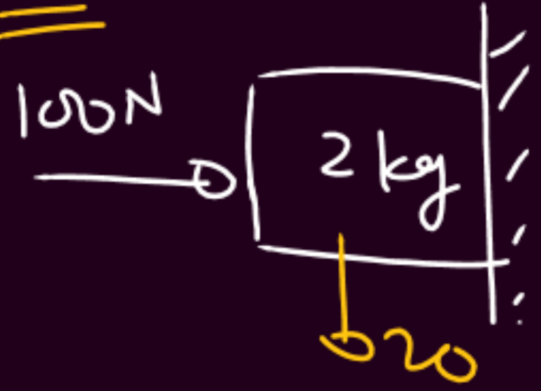


$\mu = 0.4$

$F_{min} = \frac{mg}{\mu} = \frac{40}{0.4}$

$= 100N$

Q.



$\mu = 0.5$

$f = ?$

$a = ?$

① $N = 100\,N$

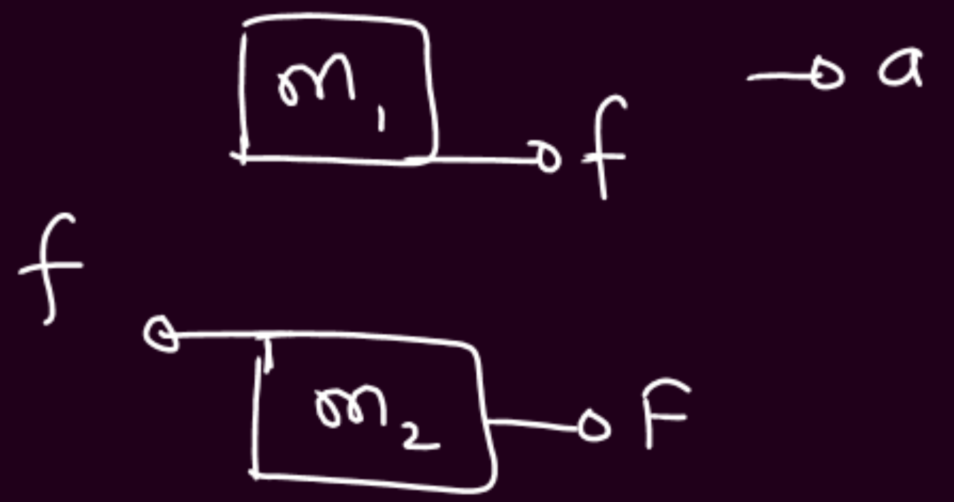
② $f_L = 0.5(100) = 50N$

③ $f_s = mg = \underline{\underline{20\,N}}$

④ $a = 0$

Two Block

①

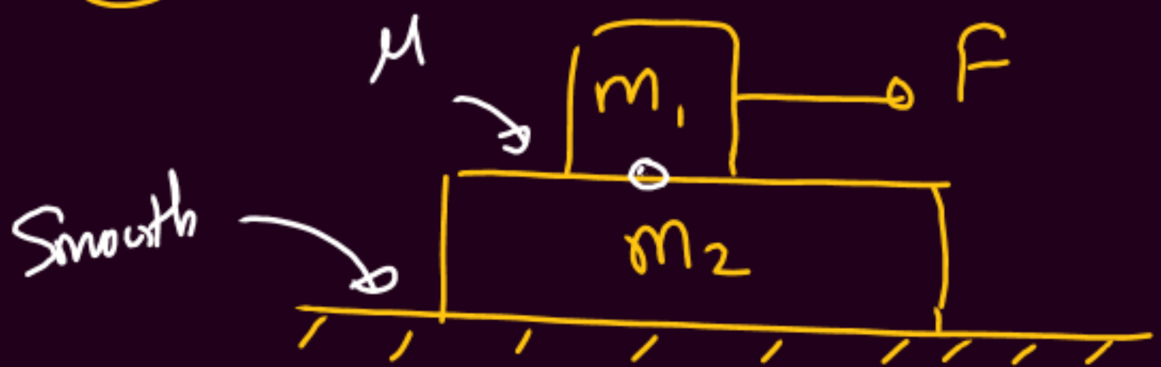


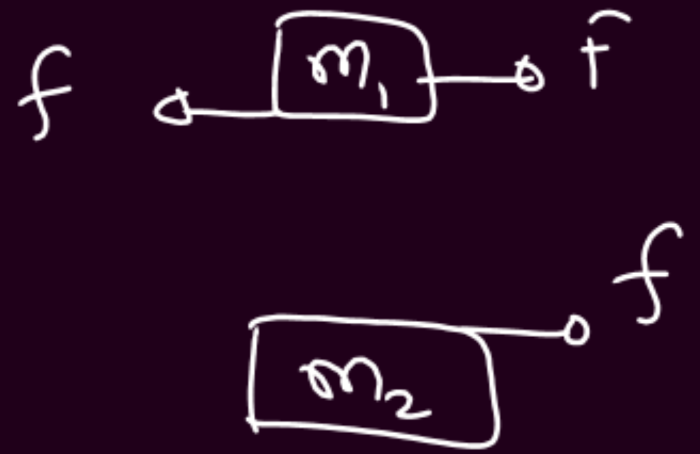
[max Acc for no Rel Motion]

$$\boxed{a_{max} = \mu g}$$

$$f_{max} = \mu m_1 g$$

② Extra





$$a_{max} = \frac{\mu m_1 g}{m_2}$$

$a_{max} = \mu g = 0.2(10) = 2\ m/s^2$

① $a = 1\ m/s^2$

$f = 4(1) = 4N$

$f = ma$

② $a = 4\ m/s^2$

$f_k = \mu mg = 0.2(4g) = \underline{\underline{8N}}$

③ $v^2 = 2aS$

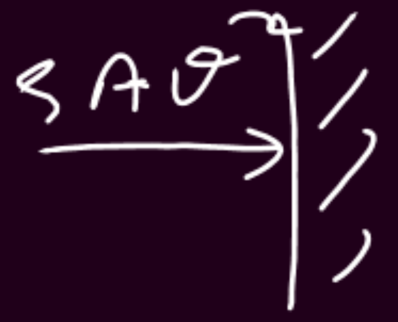
$$(100)^2 = 2\,\frac{F}{\left(\frac{5}{1000}\right)}\left(\frac{6}{100}\right)$$

① 

$$2T\cos\theta = Mg$$

$$2mg\cos\theta = Mg$$

$$\cos\theta = \frac{M}{2m} < 1$$



ρ

$$\frac{20N}{10} = 2\,\text{kg}$$

$$\frac{m(g+a)}{g}$$