Due to air drag the falling bodies usually acquire a constant speed when the drag force becomes equal to weight. Two bodies, of identical shape, experience air drag force proportional to square of their speed ($F_{drag} = kv^2$, k is a constant). The mass ratio of two bodies is 1 : 4. Both are simultaneously released from a large height and very quickly acquire their terminal speeds. If the lighter body reaches the ground in 25 s, find the approximate time taken by the other body to reach the ground.

$a = 0$ eqm

$kv^2 = mg$

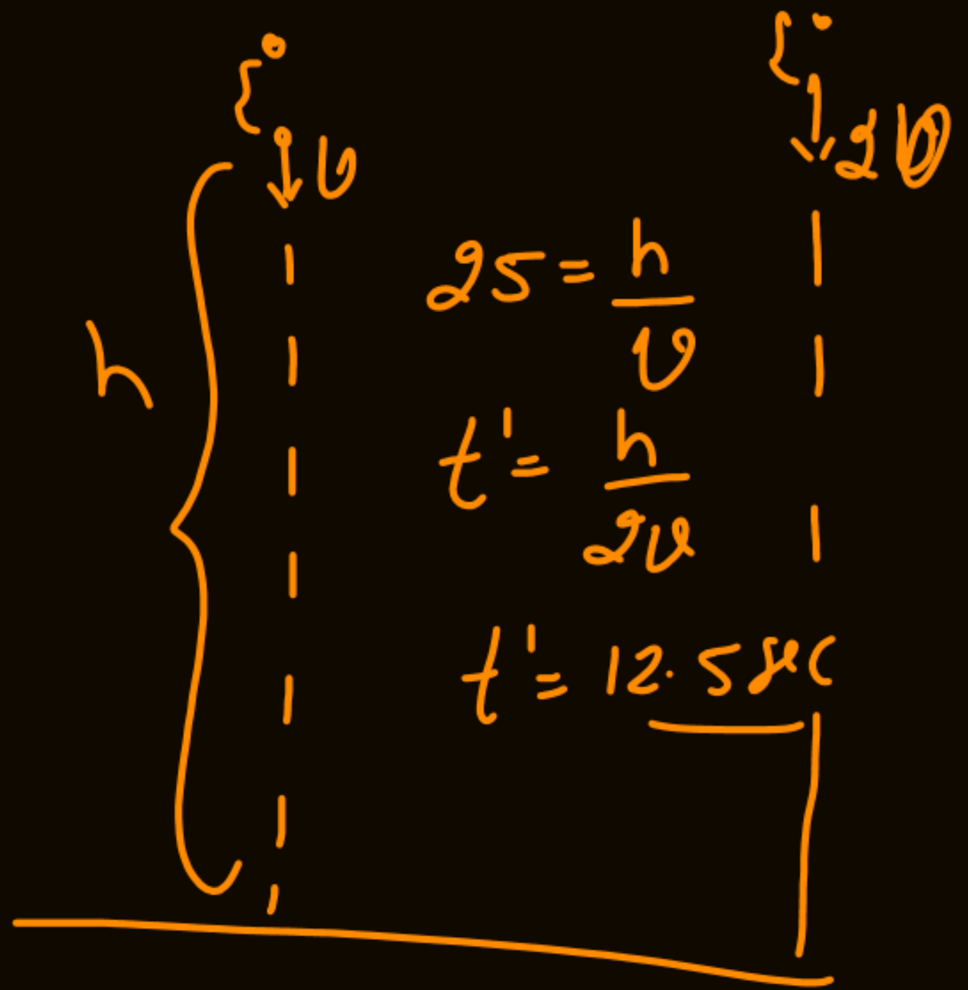
$v \propto \sqrt{m}$

$\frac{v_1}{v_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{1}{4}}$

$v_1 = \frac{v_2}{2}$

$v_1 = v$

$v_2 = 2v$

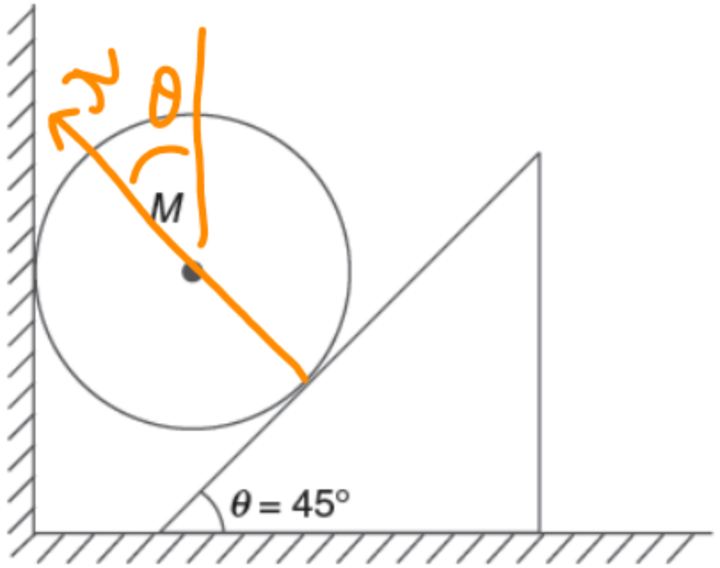


$25 = \frac{h}{v}$

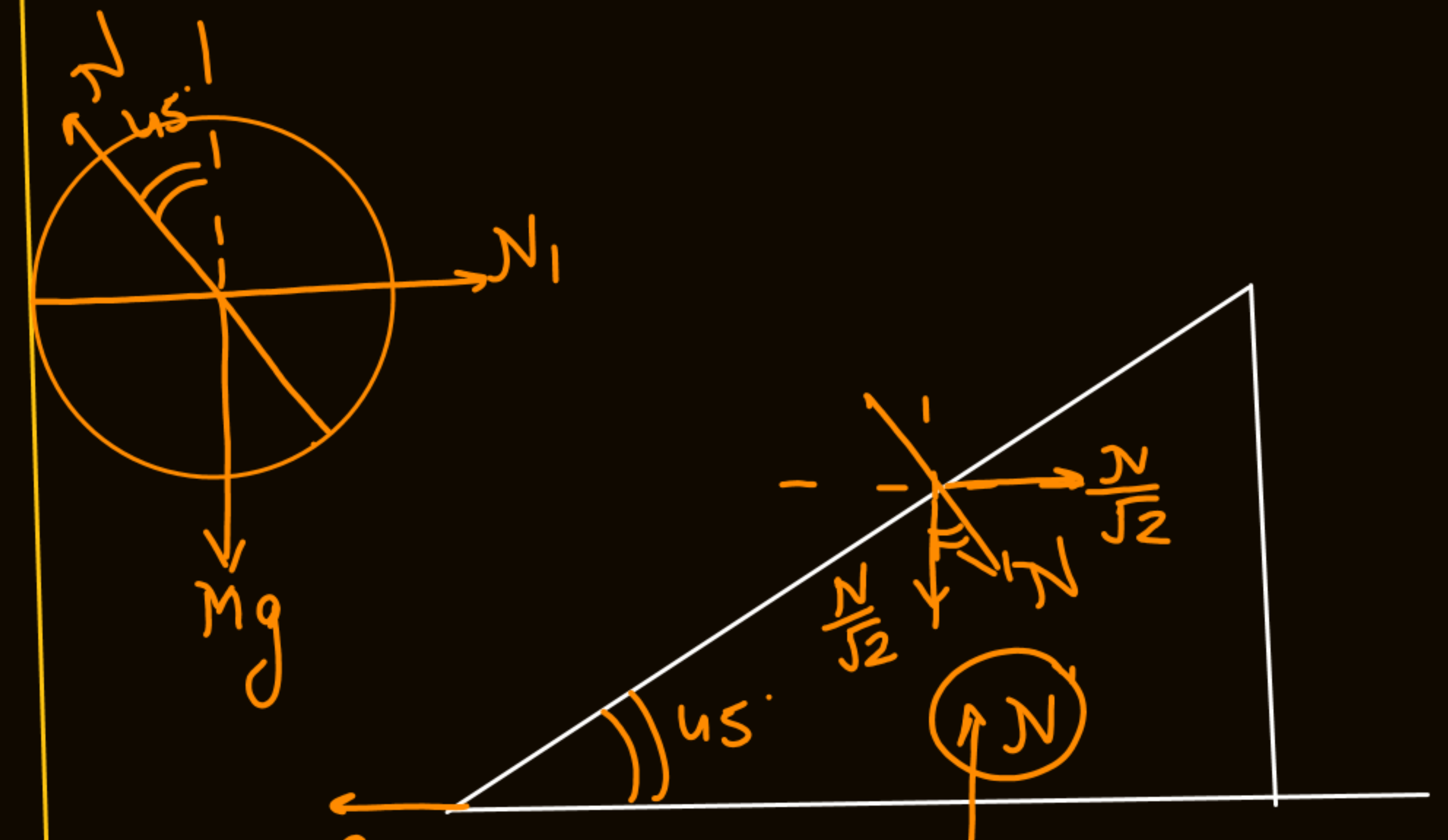
$t' = \frac{h}{2v}$

$t' = 12.5$ sec

A ball of mass M is in equilibrium between a vertical wall and the inclined surface of a wedge. The inclination of the wedge is $\theta = 45°$ and its mass is very small compared to that of the ball. The coefficient of friction between the wedge and the floor is μ and there is no friction elsewhere. Find minimum value of μ for which this equilibrium is possible.



$$\frac{N}{\sqrt{2}} = Mg \Rightarrow N = \sqrt{2}Mg$$



$$f_s = \frac{N}{\sqrt{2}} = Mg \leq \mu N'$$

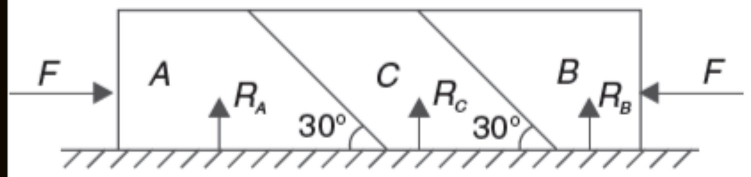
$$N' = \frac{N}{\sqrt{2}} = Mg$$

$$Mg \leq \mu Mg$$

$$\mu \geq 1$$

$$\mu_{min} = 1$$

Three blocks A, B and C each of mass m are placed on a smooth horizontal table. There is no friction between the contact surfaces of the blocks as well. Horizontal force F is applied on each of A and B as shown. Find the ratio of normal force applied by the table on the three blocks (i.e., $R_A : R_B : R_C$). Take $F = \frac{mg}{2\sqrt{3}}$



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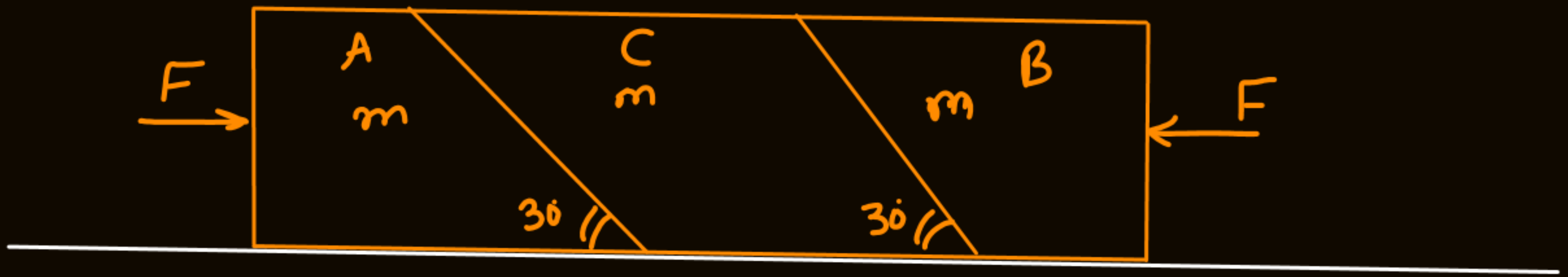
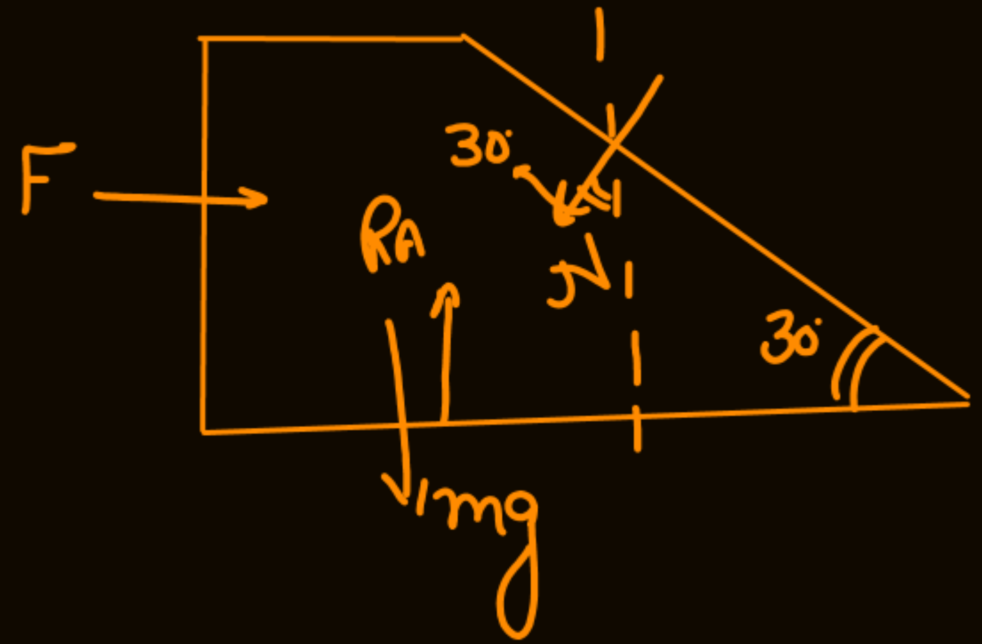


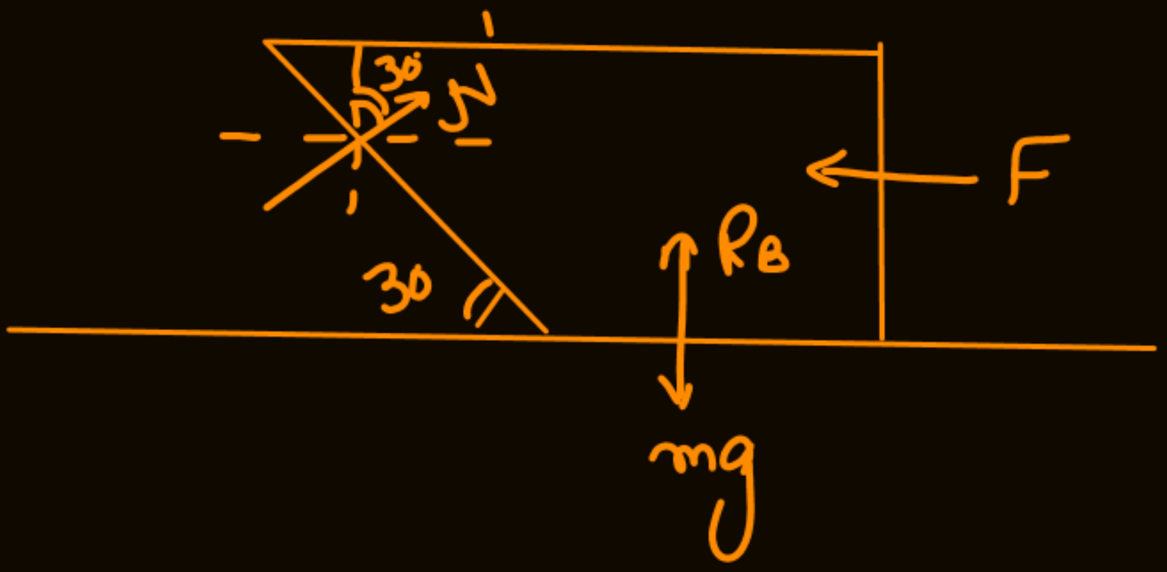


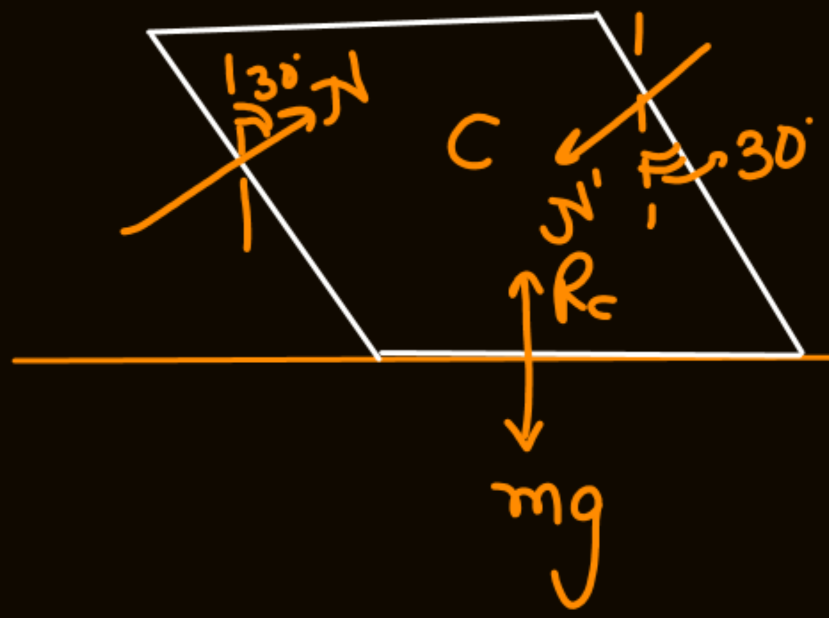
$F = N\sin 30^\circ$

$N\cos 30^\circ + mg = R_A$

$F\cot 30^\circ + mg = R_A$

$\frac{mg}{2\sqrt{3}} \times \sqrt{3} + mg = \boxed{\frac{3}{2}mg = R_A}$





$$R_c = mg$$

$$F = N' \sin 30°$$

$$R_B + N' \cos 30° = mg$$

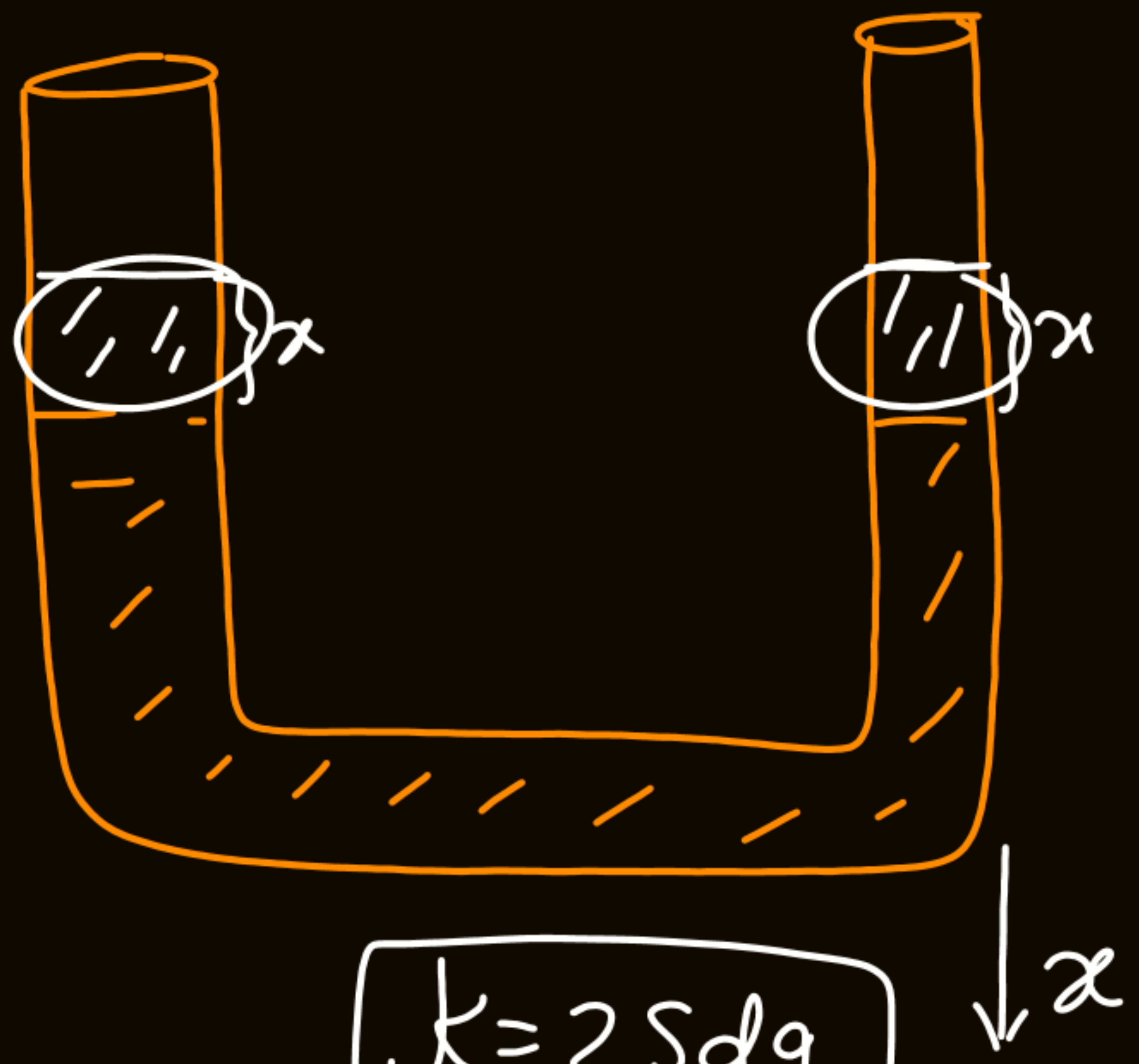
$$R_B = mg - F \cot 30$$

$$= mg - \frac{mg}{2\sqrt{3}} \times \sqrt{3}$$

$$= \frac{mg}{2}$$

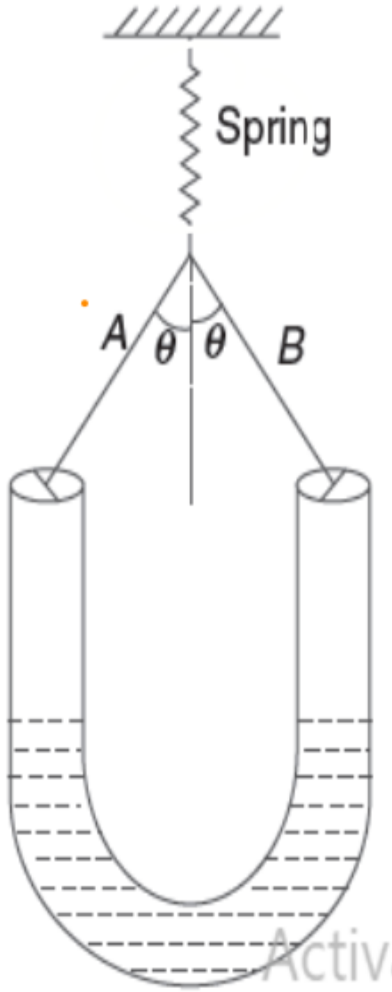
$$N' = 2F$$

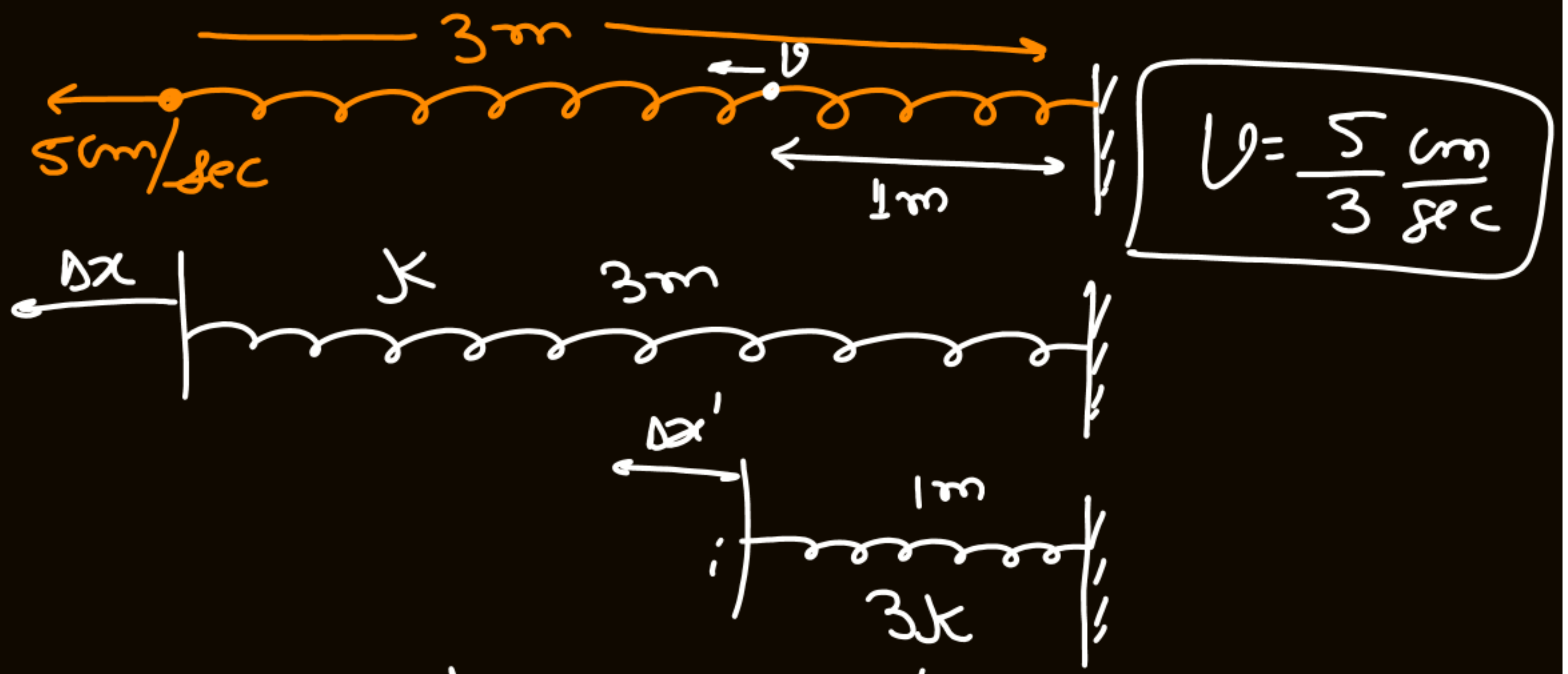
eq^n $(2Sx)dg = kx$



$$k = 2Sdg$$

A U shaped container has uniform cross sectional area S. It is suspended vertically with the help of a spring and two strings A and B as shown in the figure. The spring and strings are light. When water (density = d) is poured slowly into the container it was observed that the level of water remained unchanged with respect to the ground. Find the force constant of the spring.





$$v = \frac{5}{3}\ \frac{cm}{sec}$$

$$K\Delta x = 3K\Delta x'$$

$$\Delta x' = \frac{\Delta x}{3}$$

$$\Delta x = 5\frac{cm}{sec} \times 2\ sec = 10\ cm$$

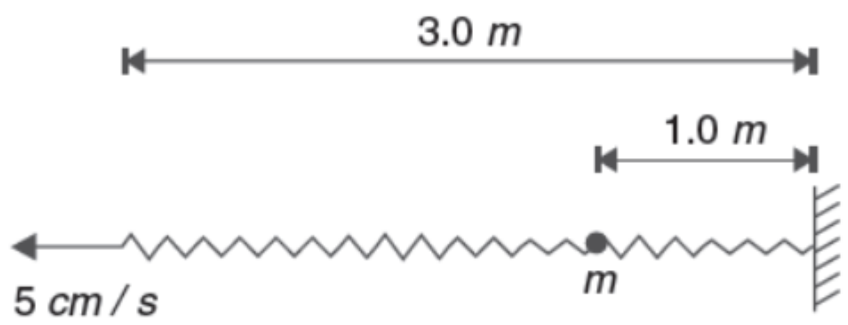
$$F = K\Delta x = 0.6\frac{N}{cm} \times 10\ cm = 6N$$

A uniform light spring has unstretched length of 3.0 *m*. One of its end is fixed to a wall. A particle of mass $m = 20\ g$ is glued to the spring at a point 1.0 m away from its fixed end. The free end of the spring is pulled away from the wall at a constant speed of 5 *cm*/*s*.

Assume that the spring remains horizontal (i.e., neglect gravity). Force constant of spring = 0.6 N/*cm*.

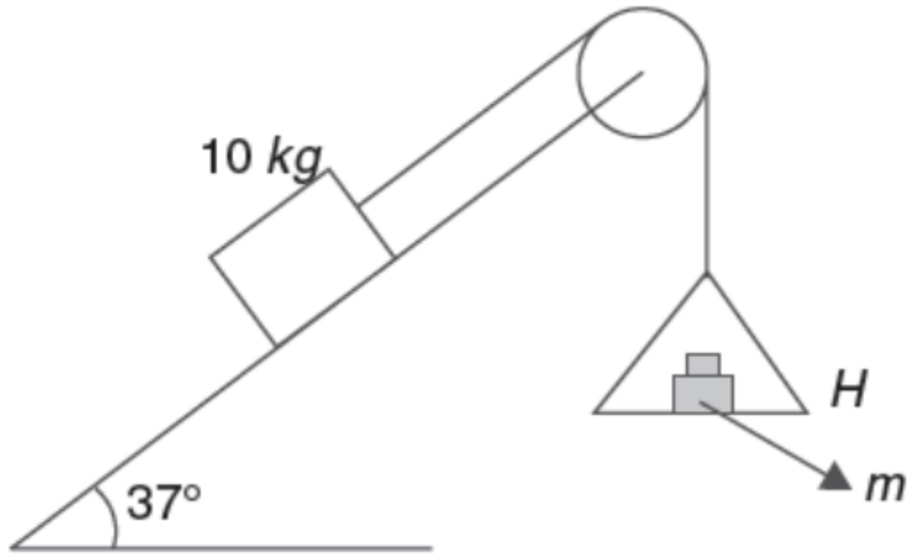
(a) With what speed does the particle of mass *m* move?

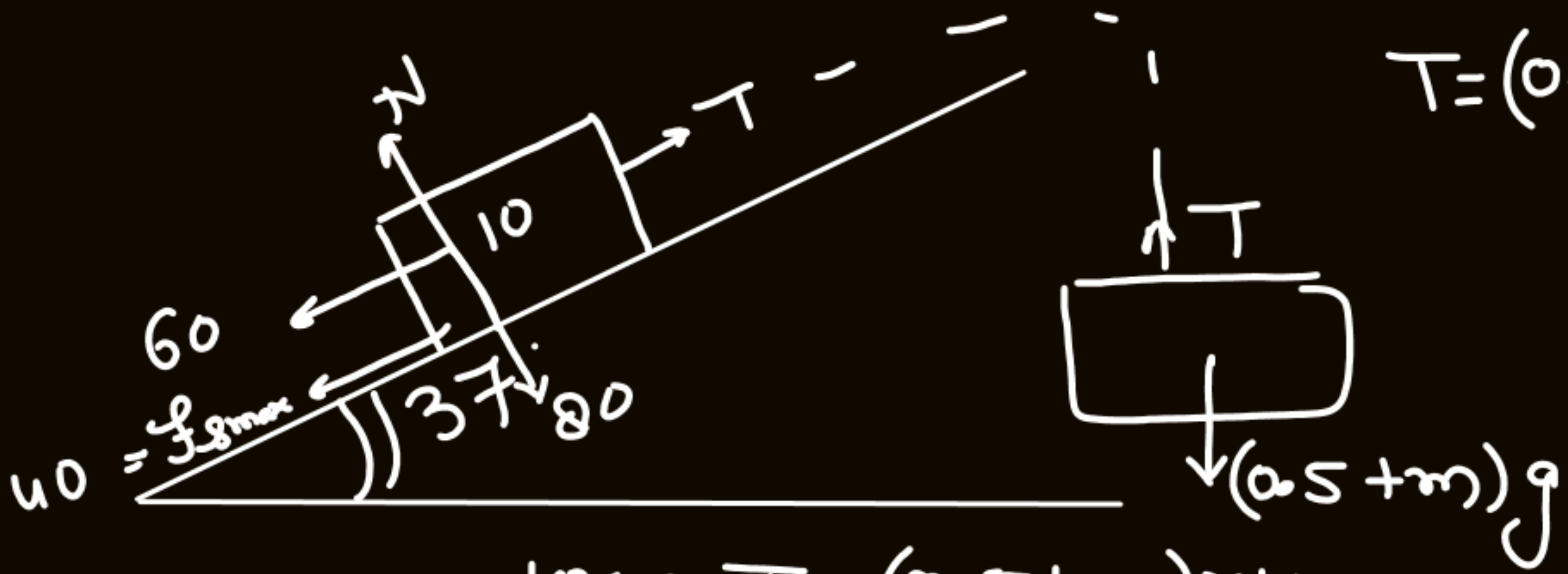
(b) Find the force applied by the external agent pulling the spring at time 2.0 s after he started pulling.



In the system shown in the figure, the string is light and coefficient of friction between the 10 *kg* block and the incline surface is $\mu = 0.5$. Mass of the hanger, *H* is 0.5 *kg*. A boy places a block of mass *m* on the hanger and finds that the system does not move. What could be values of mass *m*?

$\tan 37^\circ = \frac{3}{4}$ *and* $g = 10\ \text{m/s}^2$





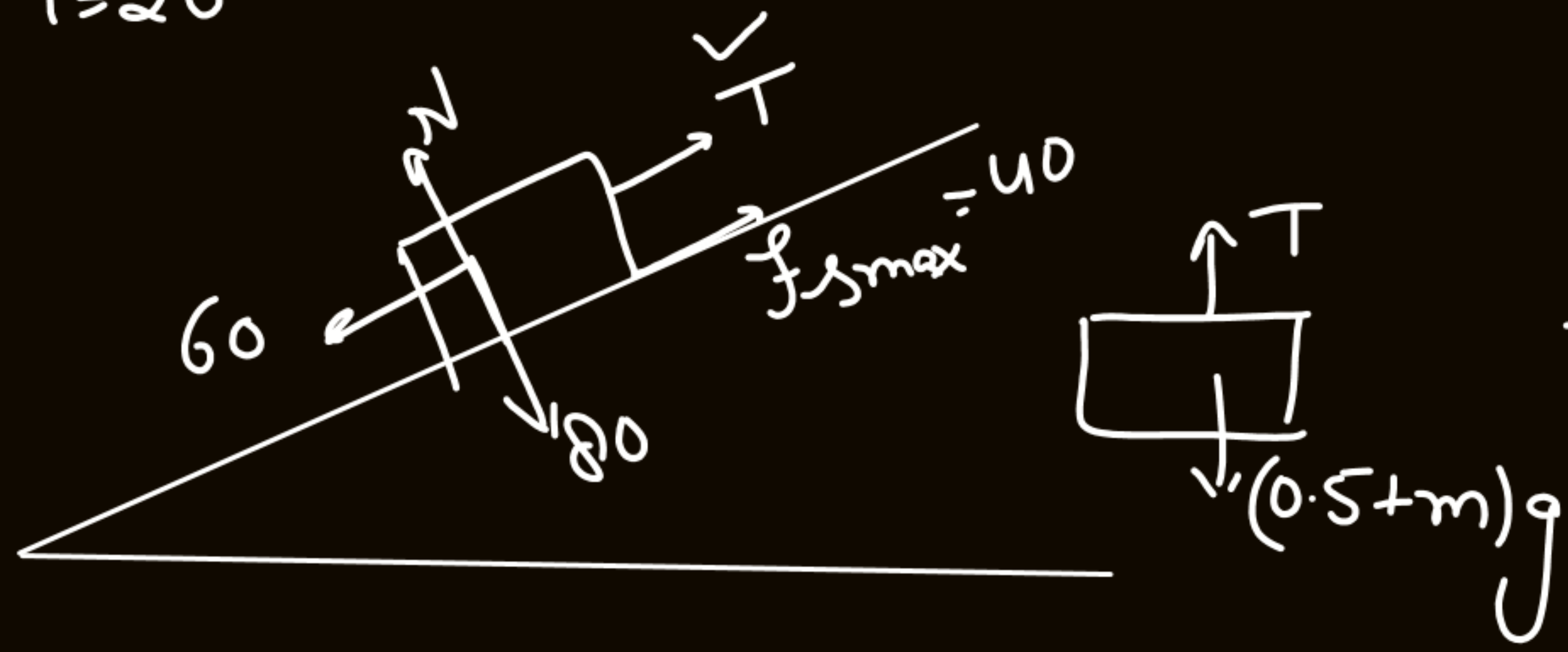
$T = (0.5+m)g$

$100 = T = (0.5+m) \times 10$

$m_{max} = 9.5\,kg$

$T + 40 = 60$

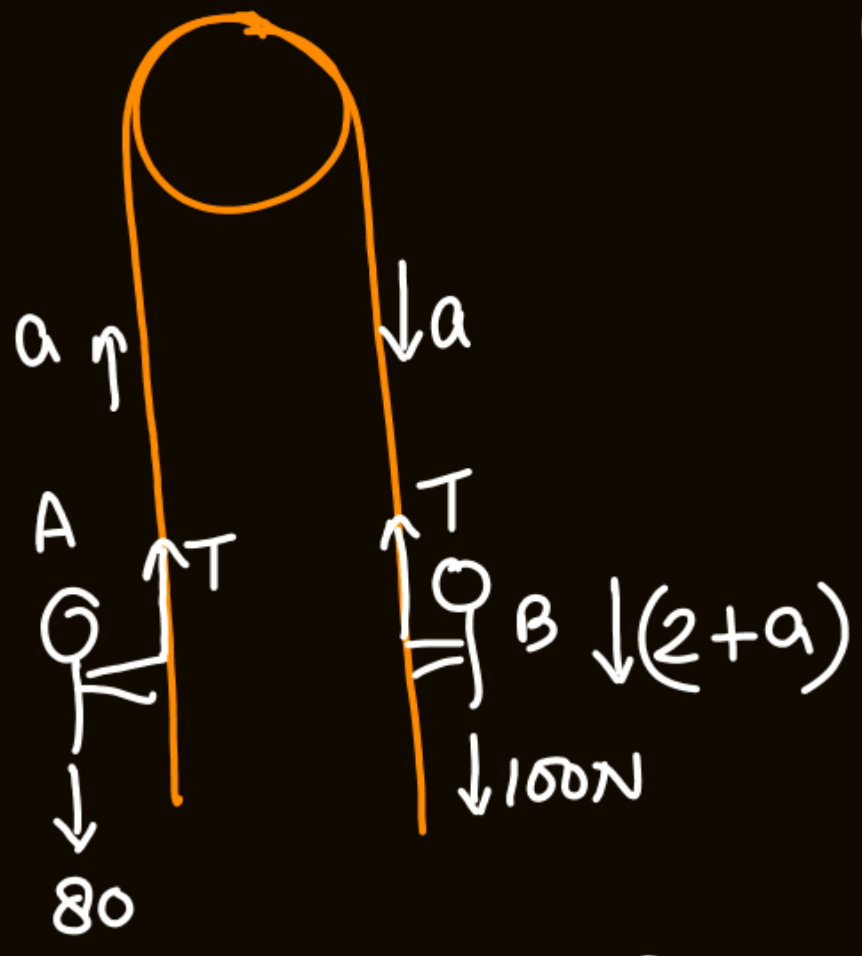
$T = 20$



$T = 20 = (0.5+m) \times 10$

$m = 1.5\,kg$

Sol:-



$$T - 80 = 8 \times a \quad \text{—(1)}$$

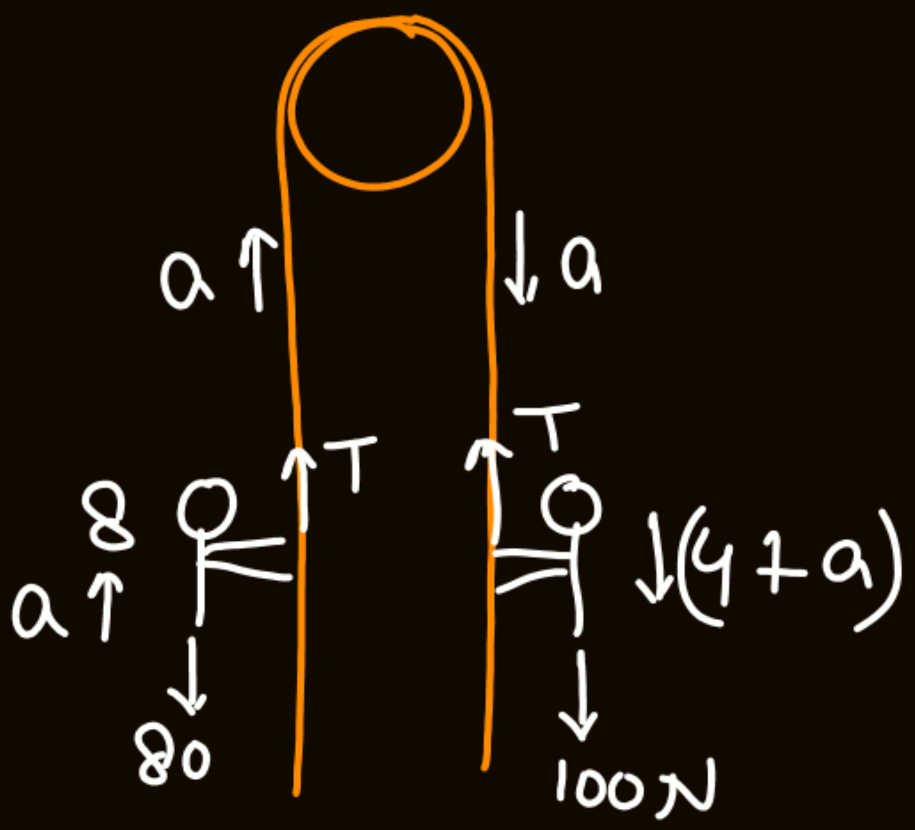
$$100 - T = 10(2+a) \quad \text{—(2)}$$

$$20 = 20 + 18a$$

$$a = 0$$

$$T = 80N$$

(b)



$$T - 80 = 8a \quad \text{—(1)}$$

$$100 - T = 10(4+a) \quad \text{—(2)}$$

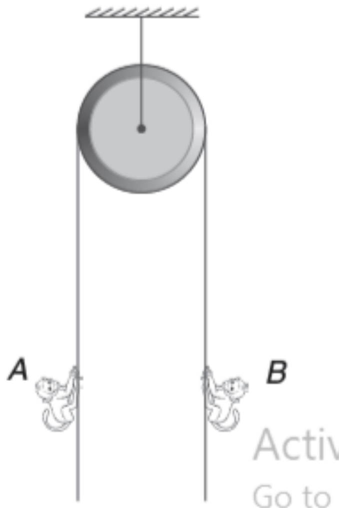
$$20 = 40 + 18a$$

$$a = \frac{-20}{18} = \frac{-10}{9}$$

Two monkeys A and B are holding on the two sides of a light string passing over a smooth pulley. Mass of the two monkeys are $m_A = 8\ kg$ and $m_B = 10\ kg$ respectively $[g = 10\ m/s^2]$

(a) Monkey A holds the string tightly and B goes down with an acceleration $a_r = 2\ m/s^2$ relative to the string. Find the weight that A feels of his own body.

(b) What is the weight experienced by two monkeys if A holds the string tightly and B goes down with an acceleration $a_r = 4\ m/s^2$ relative to the string.

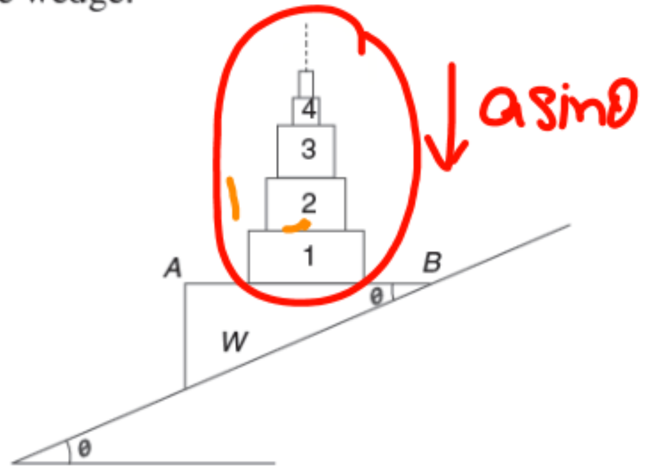


$$T = 80 + 8\left(\frac{-10}{9}\right)$$

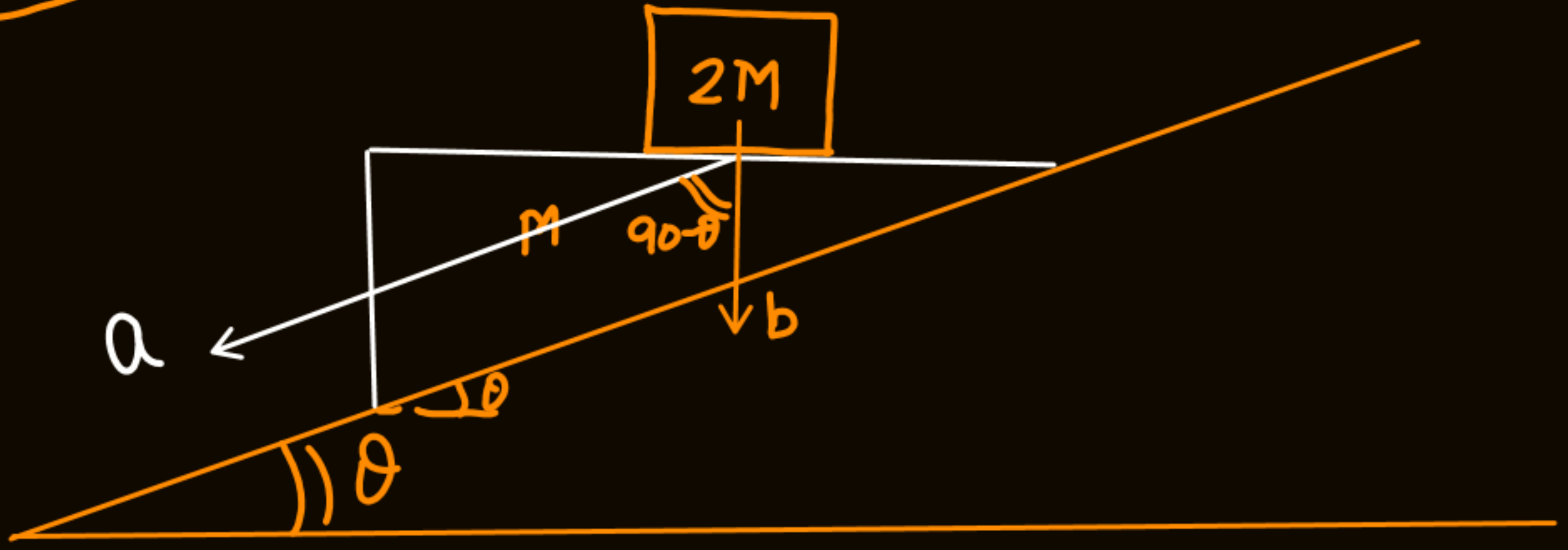
$$= 80 - \frac{80}{9}$$

$$= \frac{640}{9} N$$

A triangular wedge W having mass M is placed on an incline plane with its face AB horizontal. Inclination of the incline is θ. On the flat horizontal surface of the wedge there lies an infinite tower of rectangular blocks. Blocks 1, 2, 3, 4 .... have masses $M, \frac{M}{2}, \frac{M}{4}, \frac{M}{8}$ ....respectively. All surfaces are smooth. Find the contact force between the block 1 and 2 after the system is released from rest. Also find the acceleration of the wedge.

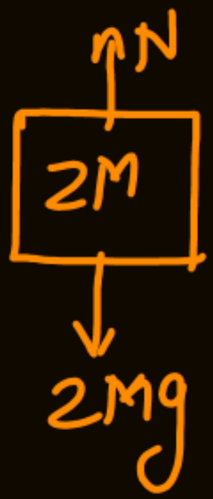


Sol:-



$M + \frac{M}{2} + \frac{M}{4} + \frac{M}{8}$ —

$\frac{M}{1-\frac{1}{2}} = 2M$



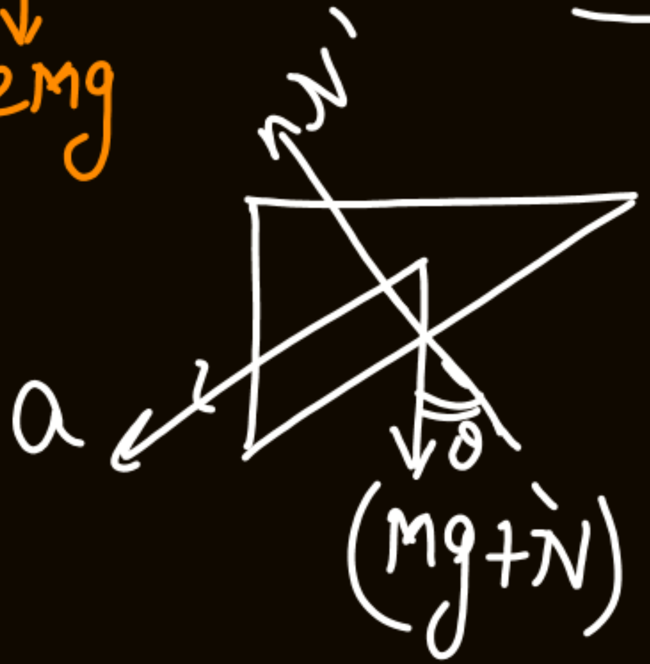
$\downarrow b = a\sin\theta$

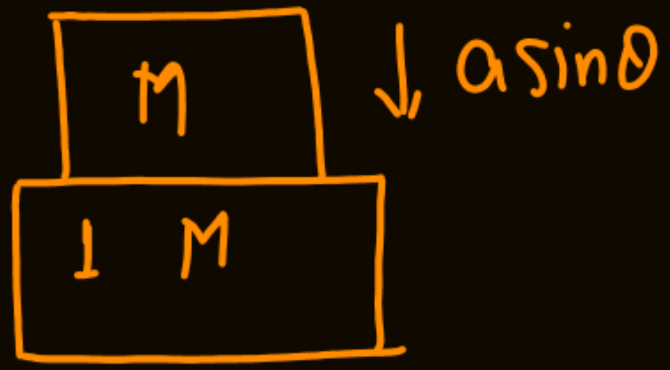
$$\{2Mg - N = (2M)a\sin\theta\}\sin\theta$$

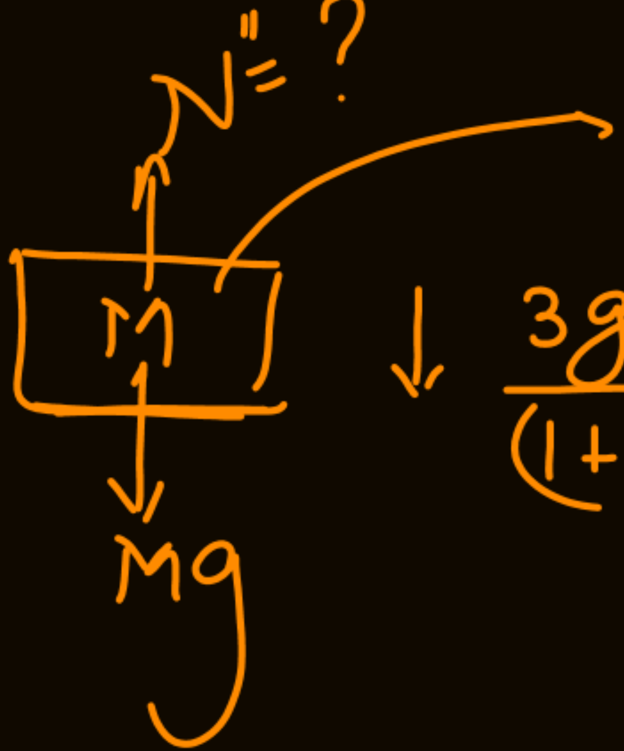
$$(Mg + N)\sin\theta = Ma$$

$$3Mg\sin\theta = (2M\sin^2\theta + M)a$$

$$a = \frac{3g\sin\theta}{(2\sin^2\theta + 1)}$$







$\downarrow \dfrac{3g\sin^2\theta}{(1+2\sin^2\theta)}$

$2+3$

$$Mg - N'' = M\,\frac{3g\sin^2\theta}{1+2\sin^2\theta}$$

$$N'' = Mg\left\{1 - \frac{3\sin^2\theta}{1+2\sin^2\theta}\right\}$$

$$T - mg = ma$$

$$2mg - T = 2ma$$

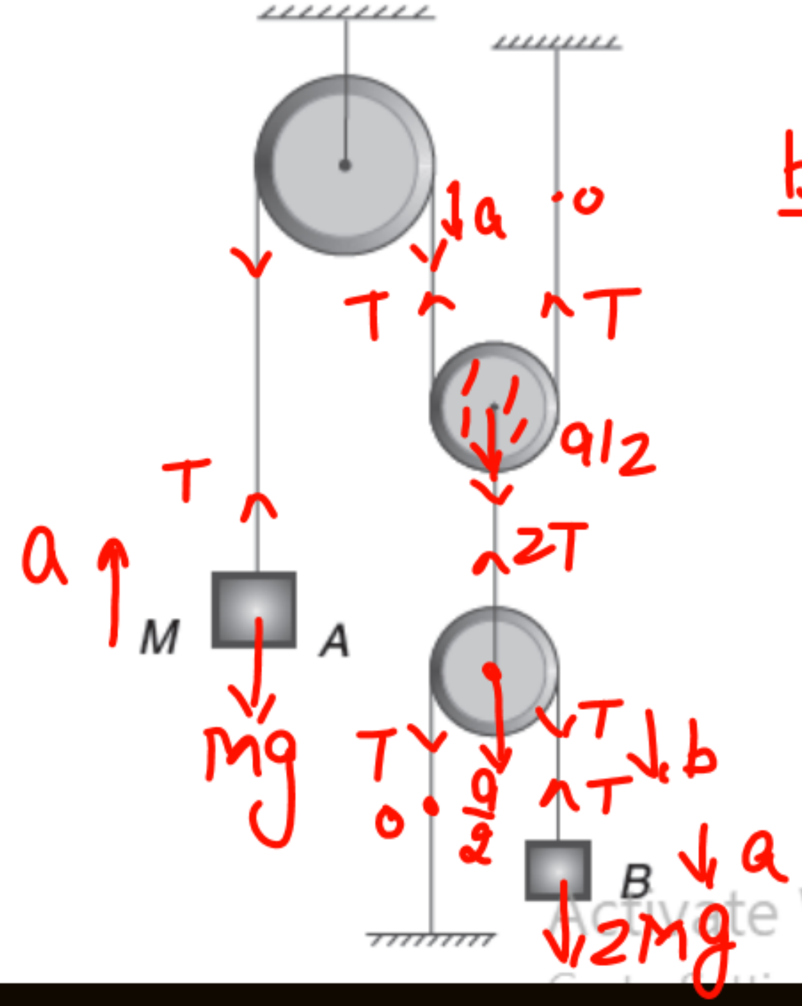
$$mg = 3ma$$

$$a = g/3$$

In the arrangement shown in the fig. all pulleys are mass less and the strings are inextensible and light. Block *A* has mass *M*.

(a) If the system stays at rest after it is released, find the mass of the block *B*.

(b) If mass of the block *B* is twice the value found in part (a) of the problem, calculate the acceleration of block *A*.



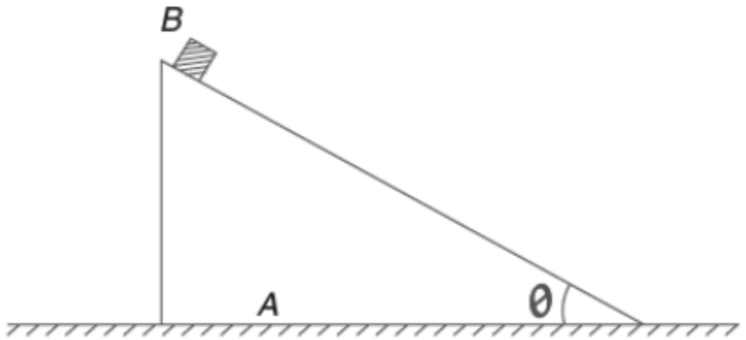
$$\frac{b+0}{2} = \frac{a}{2}$$

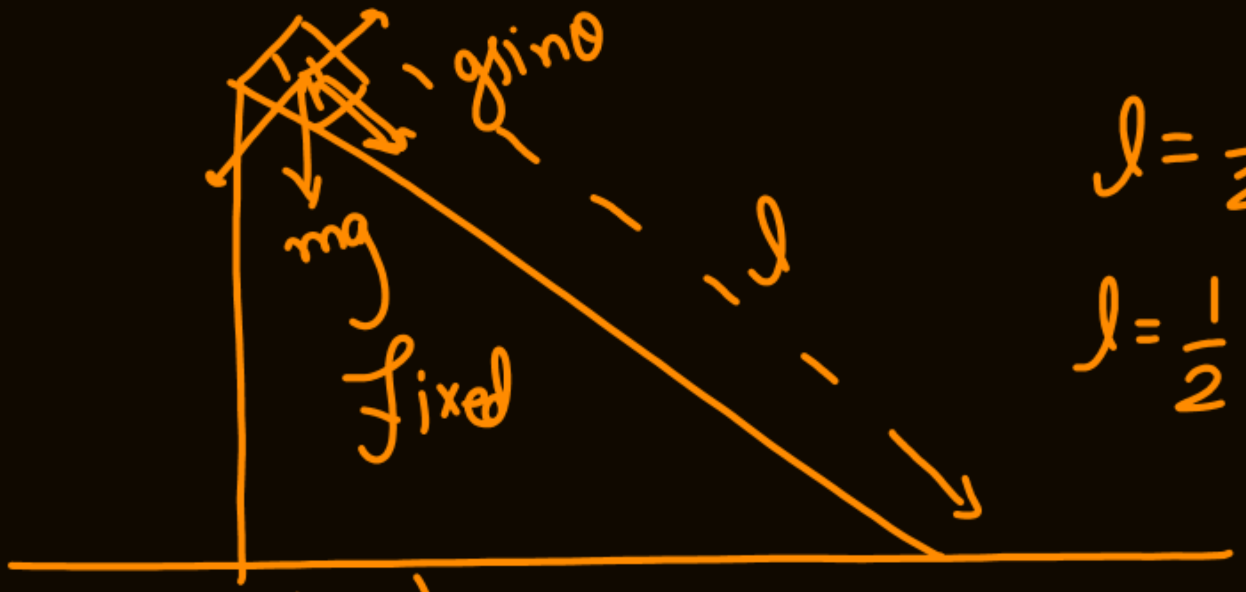
$$b = a$$

A triangular wedge A is held fixed and a block B is released on its inclined surface, from the top. Block B reaches the horizontal ground in time t. In another experiment, the wedge A was free to slide on the horizontal surface and it took t' time for the block B to reach the ground surface after it was released from the top. Neglect friction and assume that B remains in contact with A.

(a) Which time is larger t or t'? Tell by simple observation.

(b) When wedge A was free to move, it was observed that it moved leftward with an acceleration $\frac{g}{4}$ and one of the two measured times (t & t') was twice the other. Find the inclination θ of the inclined surface of the wedge.



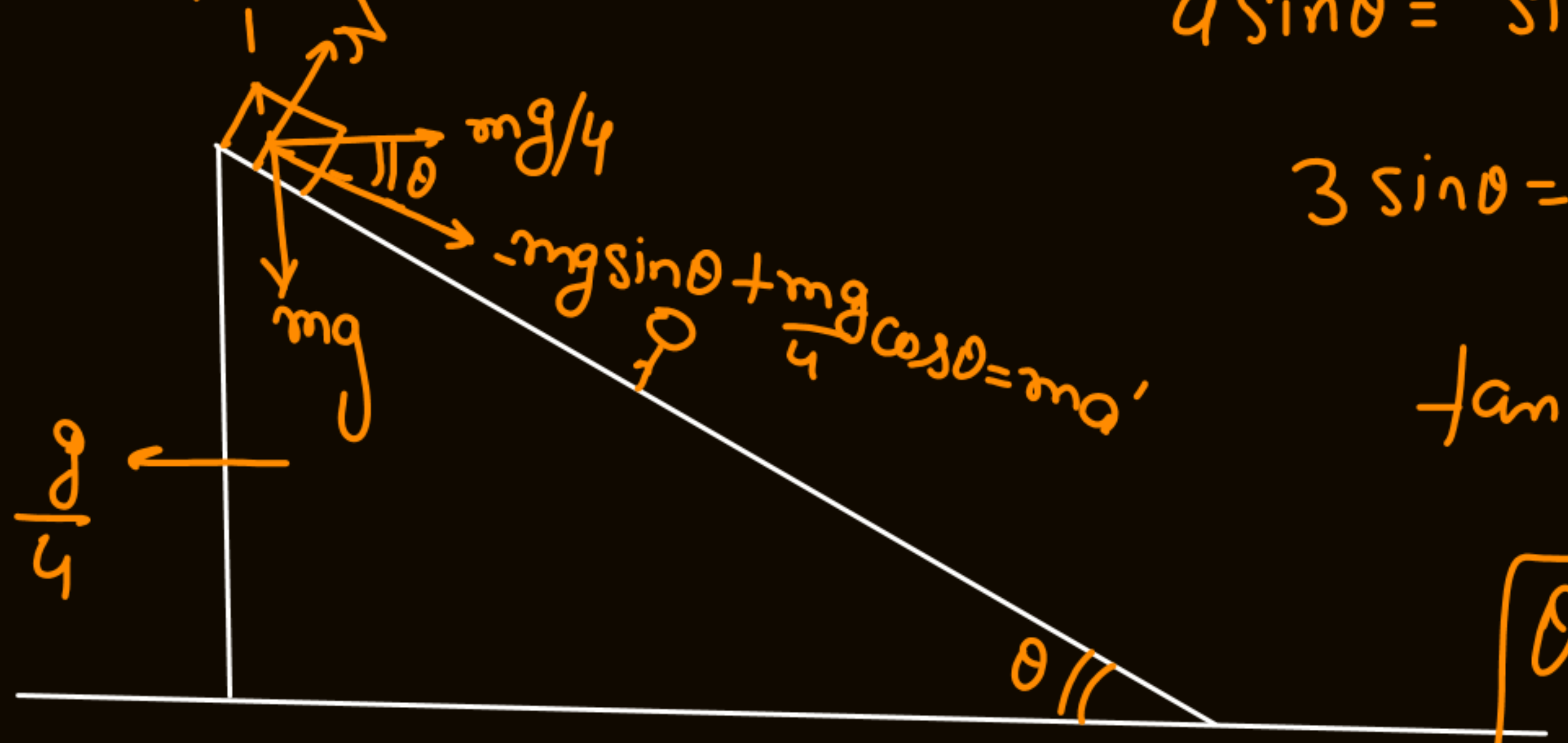


$t' < t$

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

$t' = t/2$

$$l = \frac{1}{2} g\left(\sin\theta + \frac{\cos\theta}{4}\right)\frac{t^2}{4} \quad (2)$$



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

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

$$\tan\theta = \frac{1}{12}$$

$$\theta = \tan^{-1}\left(\frac{1}{12}\right)$$