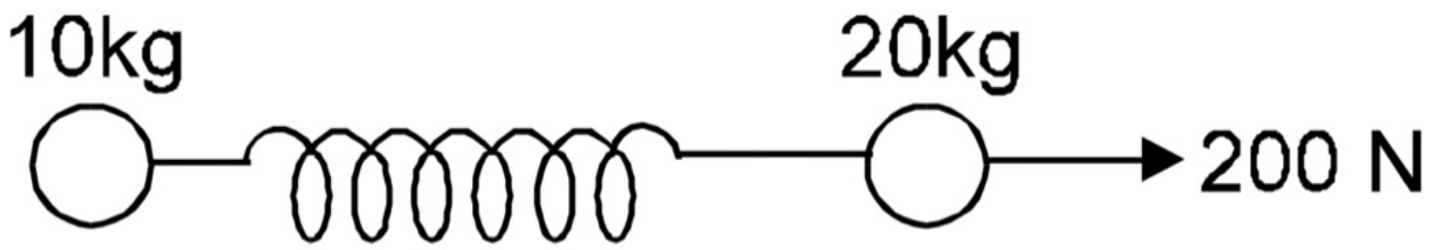
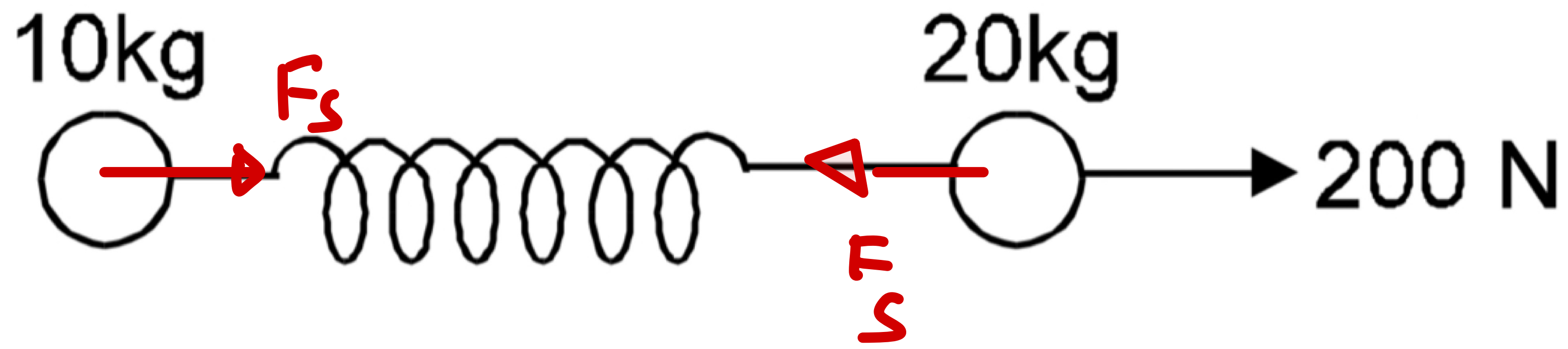
17. Two masses of 10 kg and 20 kg respectively are connected by a massless spring as shown in figure. A force of 200 N acts on the 20 kg mass at the instant when the 10 kg mass has an acceleration of 12 ms^{-2} towards right, the acceleration of the 20 kg mass is :

(A) 2 ms–2
(B) 4ms^{-2}
(C) 10ms^{-2}
(D) 20ms^{-2}





$F_s = ma$

$200 - F_s = ma$

$F_s = 10 \times 12$

$200 - 120 = 20a$

$F_s = 120N$

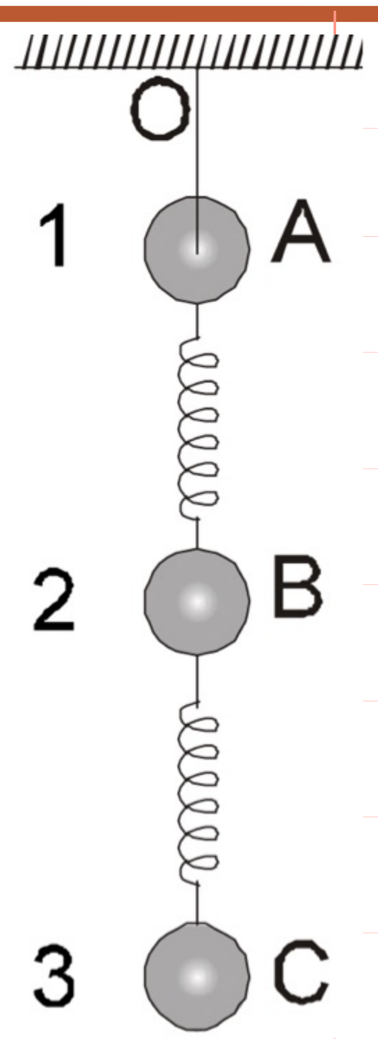
$80 = 20a$

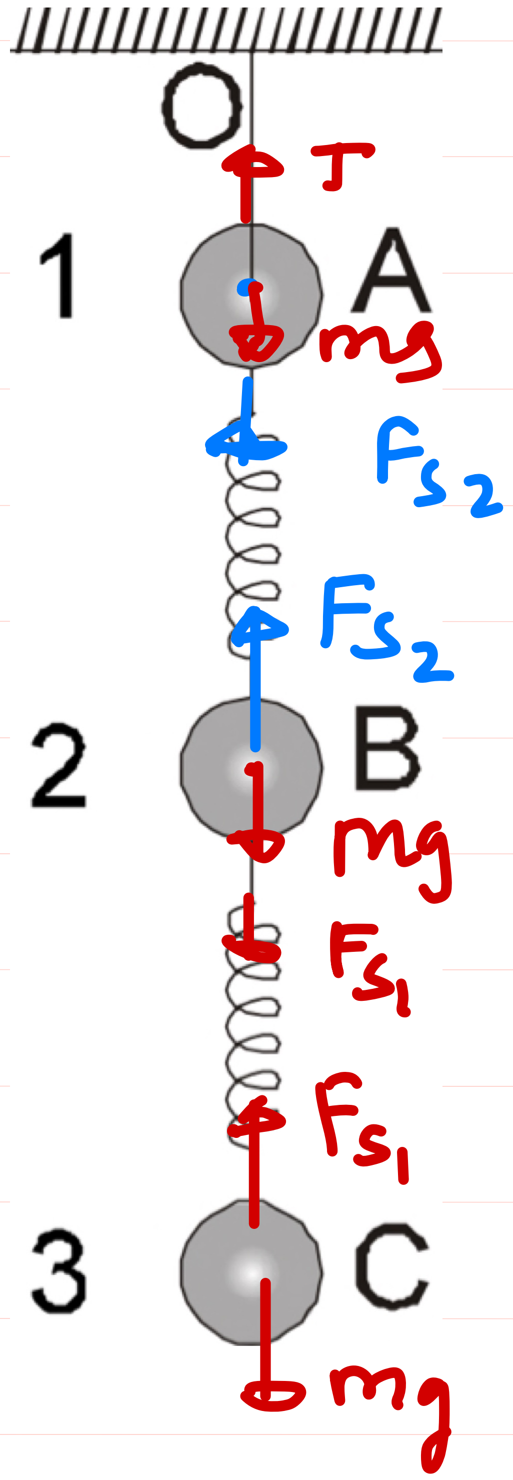
$\boxed{4 m/s^2 = a}$

10. Three identical balls 1,2,3 are suspended on springs one below the other as shown in the figure. OA is a weightless thread.

(a) If the thread is cut, the system starts falling. Find the acceleration of all the balls at the initial instant

(b) Find the initial accelerations of all the balls if we cut the spring BC which is supporting ball 3 instead of cutting the thread.





$T = F_{s_2} + mg$

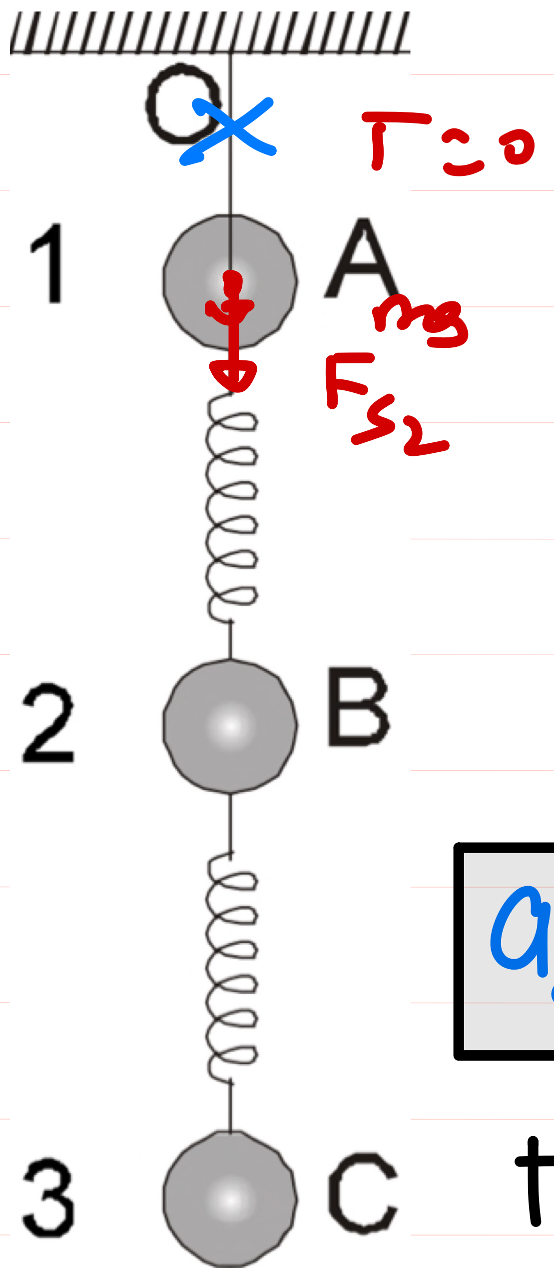
$T = 3mg$

$F_{s_2} = mg + F_{s_1}$

$F_{s_2} = 2mg$

$F_{s_1} = mg$

(a) Thread is cut



$F_{s_2} + mg = m a_A$

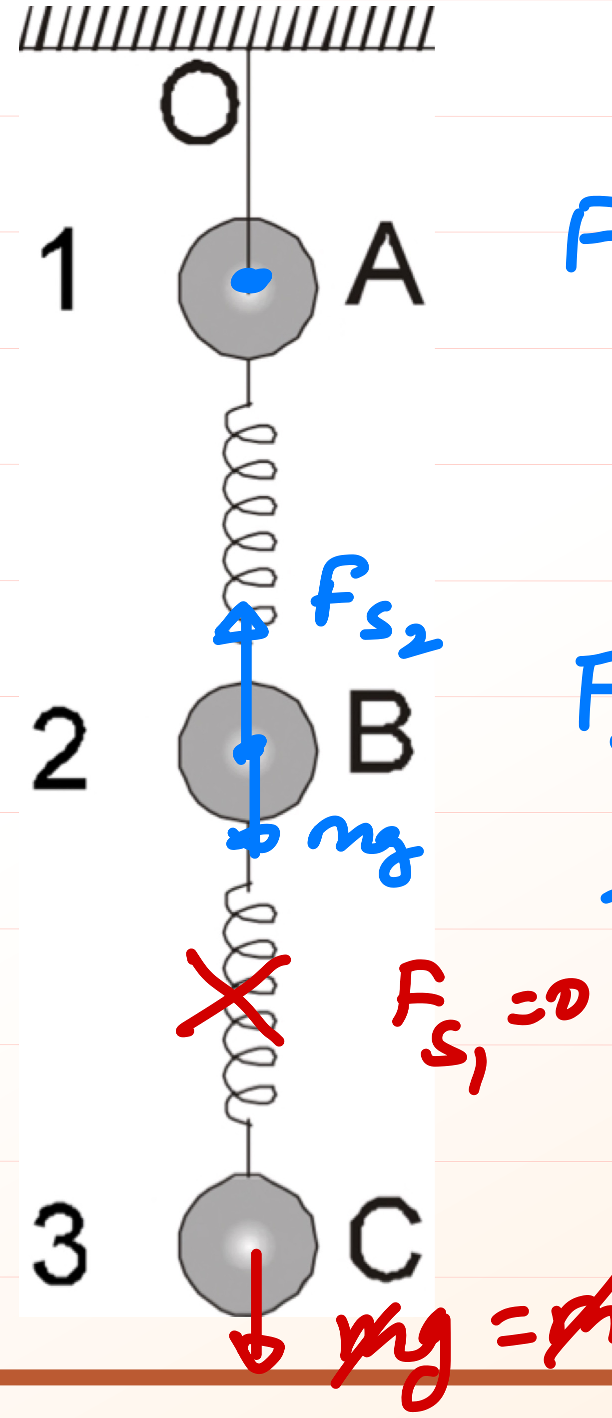
$3mg = m a_A$

$\boxed{a_A = 3g \downarrow}$ Ans

$\boxed{a_B = a_C = 0\ m/s^2}$

there is no change in forces on B and C

(b)



$F_{net} = 0 = m a_A \Rightarrow \boxed{a_A = 0\ m/s^2}$

$F_{s_2} - mg = m a_B$

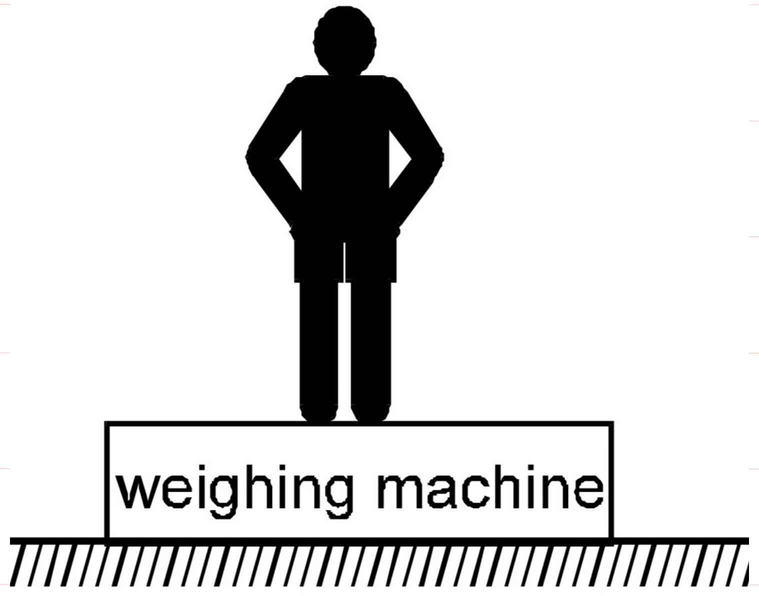
$2mg - mg = m a_B \Rightarrow \boxed{a_B = g \uparrow}$

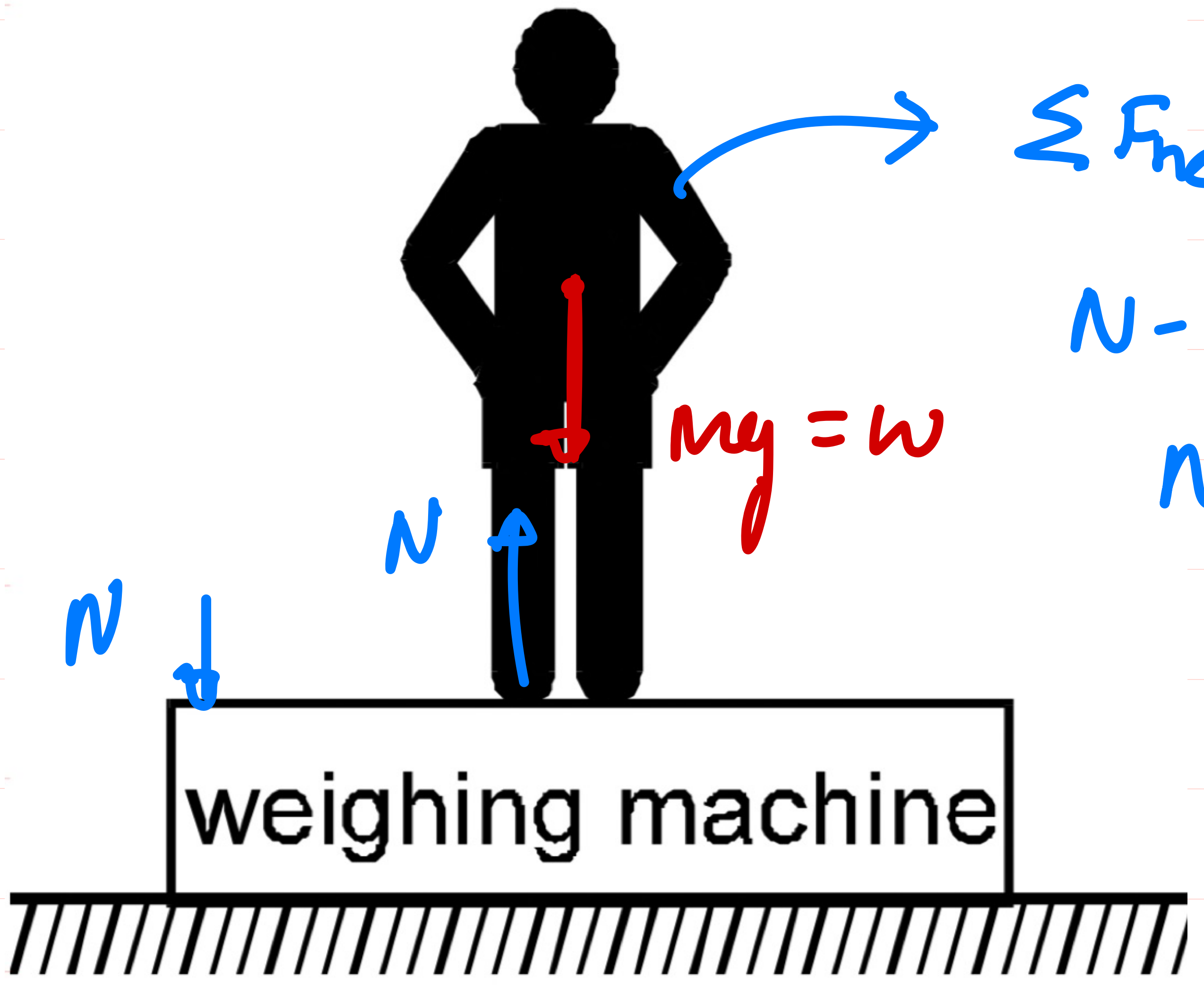
$\cancel{m}g = \cancel{m} a_C \Rightarrow \boxed{a_C = g \downarrow}$

WEIGHING MACHINE :→

A weighing machine does not measure the weight but measures the force exerted by object on its upper surface.

Illustration 15. A man of mass 60 Kg is standing on a weighing machine placed on ground. Calculate the reading of machine ($g = 10\ m/s^2$).





$\Sigma F_{net} = 0$

$N - W = 0$

$N = W$

Reading of machine $= N$

$= W$

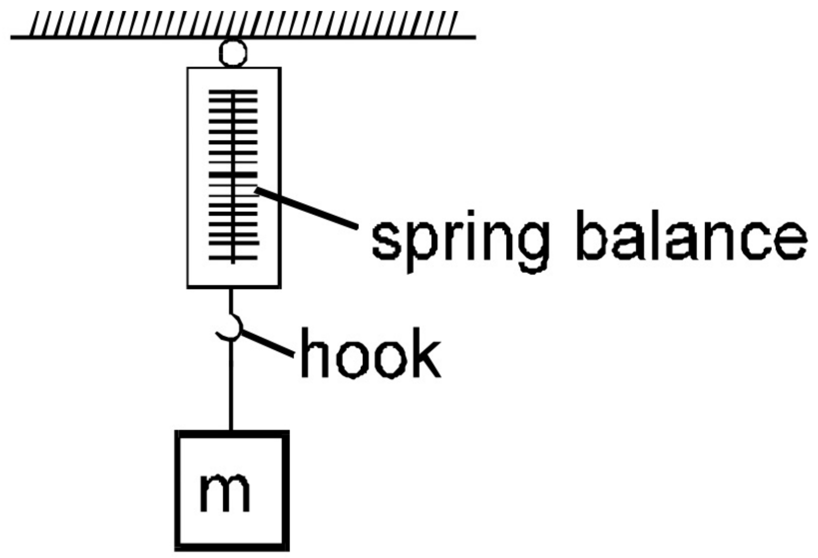
$= mg$

$= 60 \times 10$

$= 600\ N$ Ans

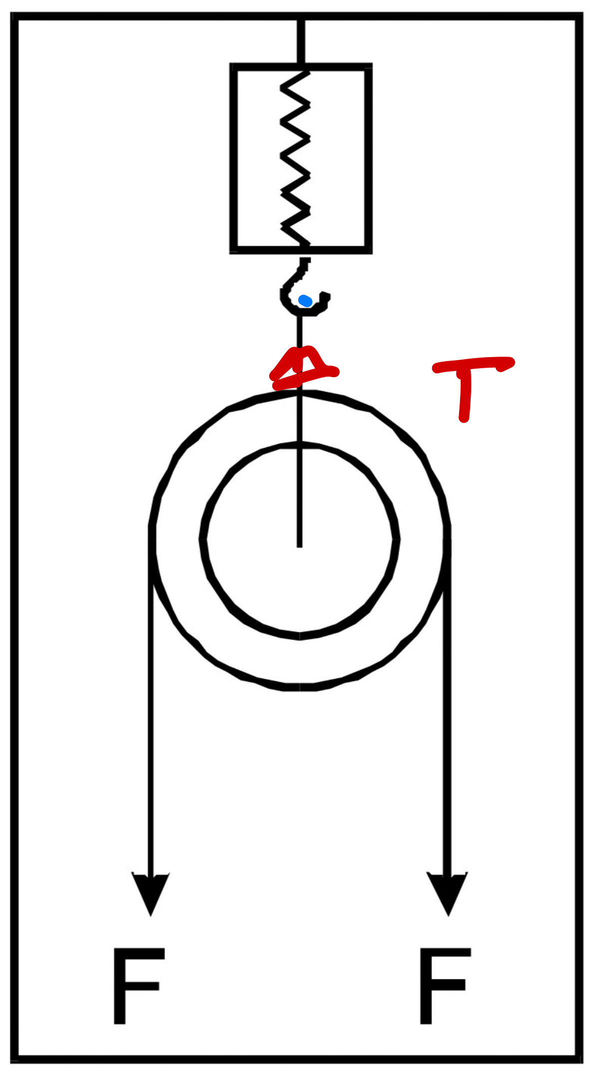
SPRING BALANCE :→

It does not measure the weight. It measures the force exerted by the object at the hook.
Symbolically, it is represented as shown in figure.
A block of mass 'm' is suspended at hook.
When spring balance is in equilibrium, we draw the F.B.D. of mass m for calculating the reading of balance.

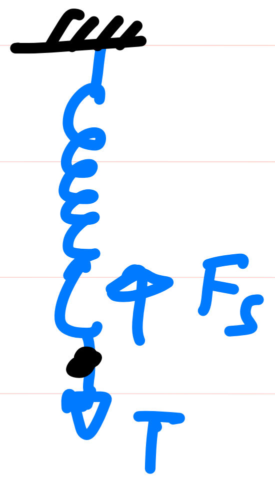


Reading = Force on Hook

Illustration 18. Find the reading of spring balance in the adjoining figure, pulley and strings are ideal.

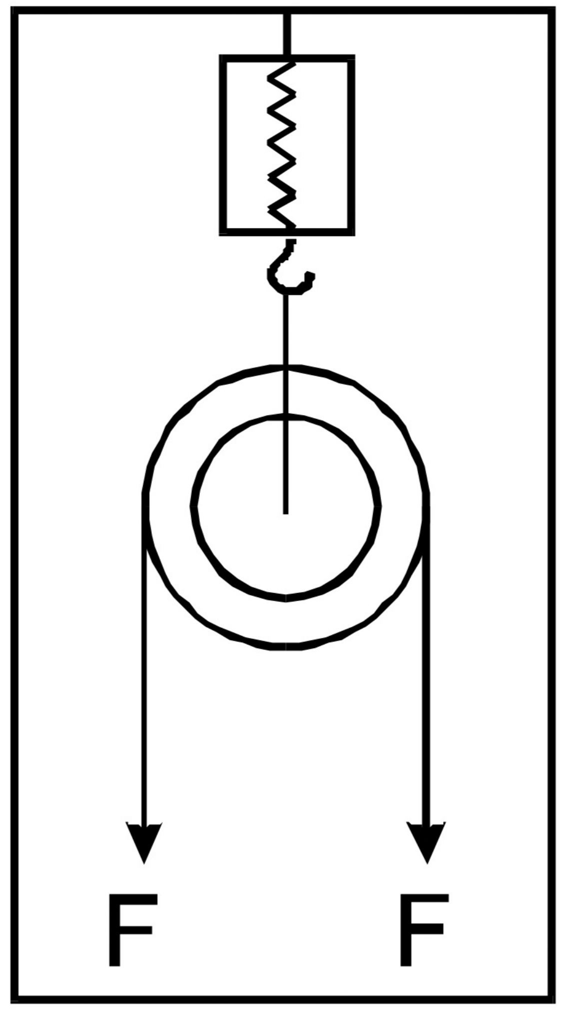


$T = 2F$

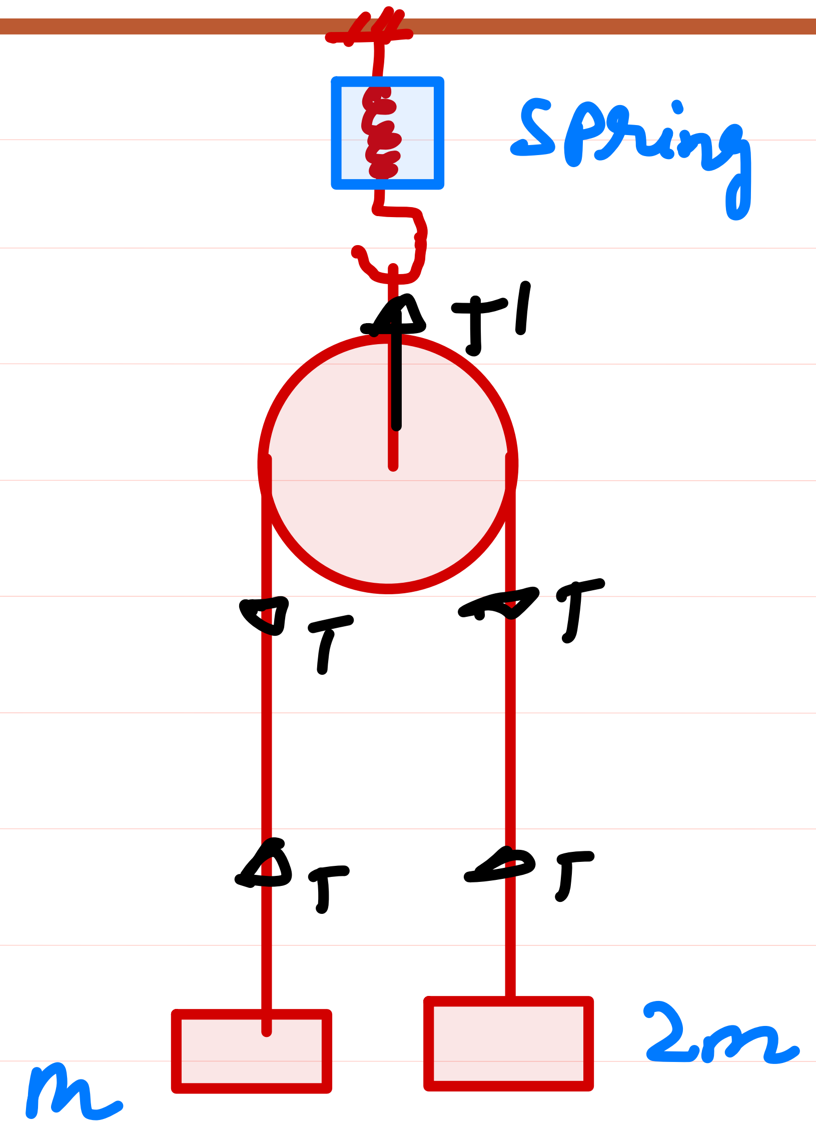


$F_s = T$

$\boxed{F_s = 2F = \text{Reading}}$



Ex



Reading of Spring

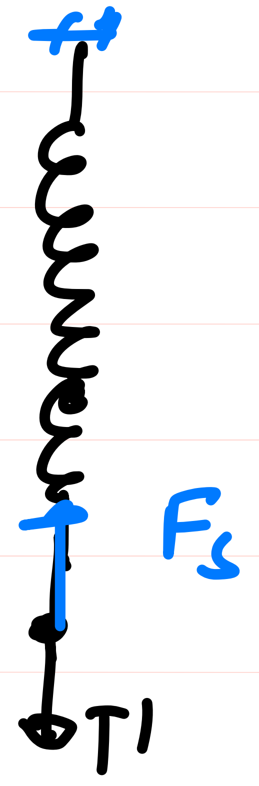
$$T = \frac{2m_1 m_2}{m_1+m_2} g$$

$$= \frac{2\,m.2m}{3m}.g$$

$$T = \frac{4mg}{3}$$

$T' = 2T$

FBD



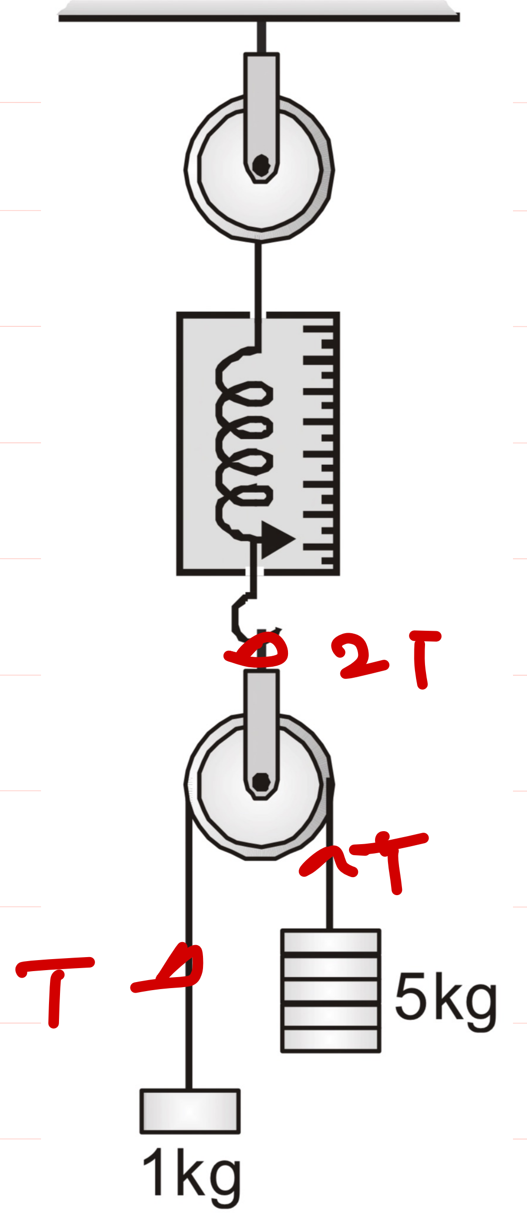
At Rest

$F_s = T'$

$F_s = 2T$

$$\boxed{F_s = \frac{8mg}{3} = \text{Reading}}$$

1. A frictionless pulley of negligible weight is suspended from a spring balance. Masses of 1 kg and 5 kg are tied to the two ends of a string which passes over the pulley. The masses move due to gravity. During motion, the reading of the spring balance will be :



(A) $\frac{5}{3}$ kg wt

(B) $\frac{10}{3}$ kg wt

(C) 6 kg wt

(D) 3 kg wt

Reading = 2T

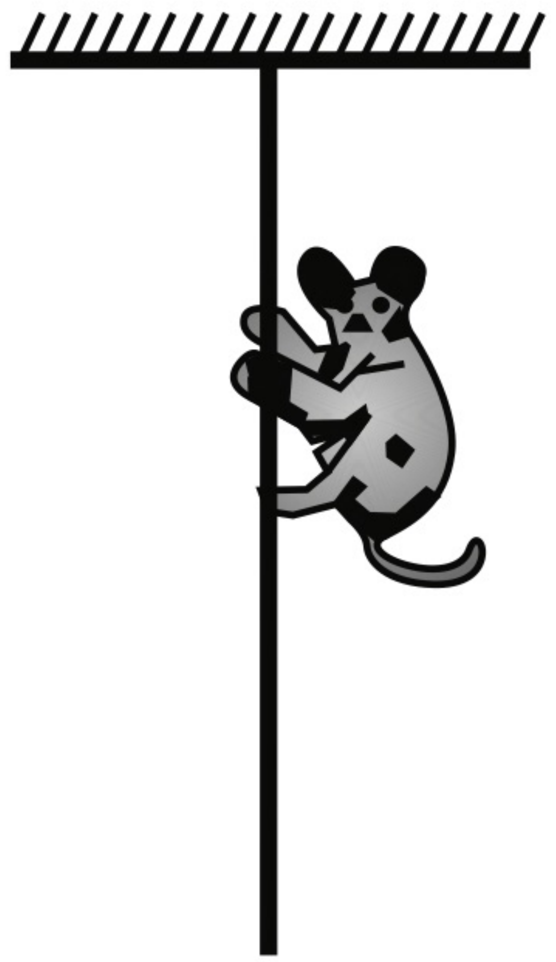
$T = \frac{2(1)(5)}{6}g$

$T = \frac{5g}{3}$

$\frac{\text{Reading}}{g} = \frac{\frac{10}{3}g}{g}$

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

Q.3 A monkey of mass 40 kg climbs on a rope which can stand a maximum tension of 600 N. In which of the following cases will the rope break: the monkey



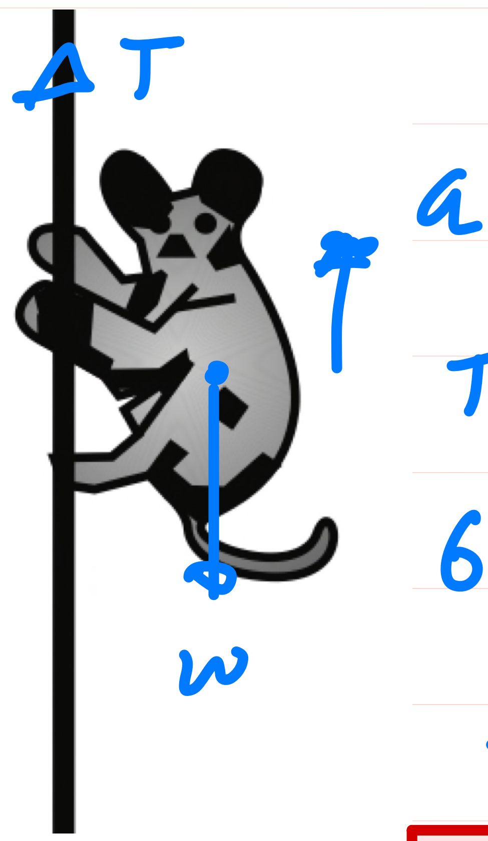
Yes (a) Climbs up with an acceleration of $6 ms^{-2}$

No (b) Climbs down with an acceleration of $4 ms^{-2}$

No (c) Climbs up with a uniform speed of $5 ms^{-1}$

No (d) Falls down the rope nearly freely under gravity.

moving upward



$T - W = ma$

$600 - 400 = 40a$

$200 = 40a$

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

If $a > 5 m/s^2$

string will break

moving with uniform velocity (v = constant)

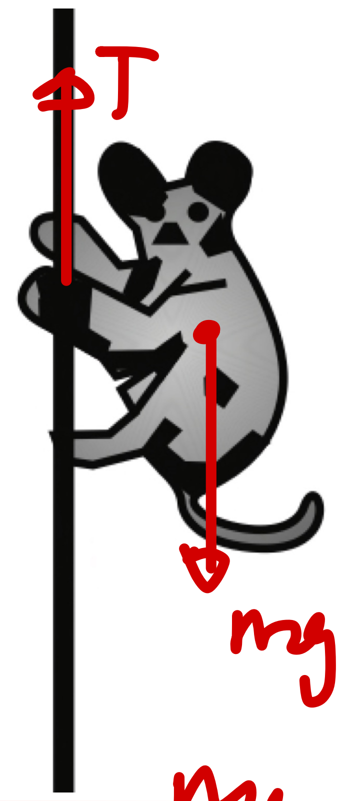
$a = 0$

$T - mg = 0$ / $mg - T = 0$

$T = mg$

$\boxed{T = 400 N}$

moving downward



$mg - T = ma$

$400 - T = 40a$

$T_{min} = 0$

$\boxed{a_{max} = 10 m/s^2}$

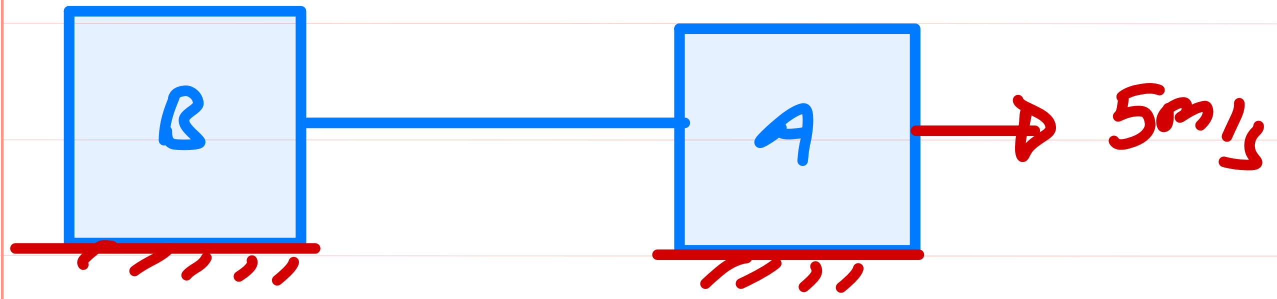
free fall

String Constraint

Ex

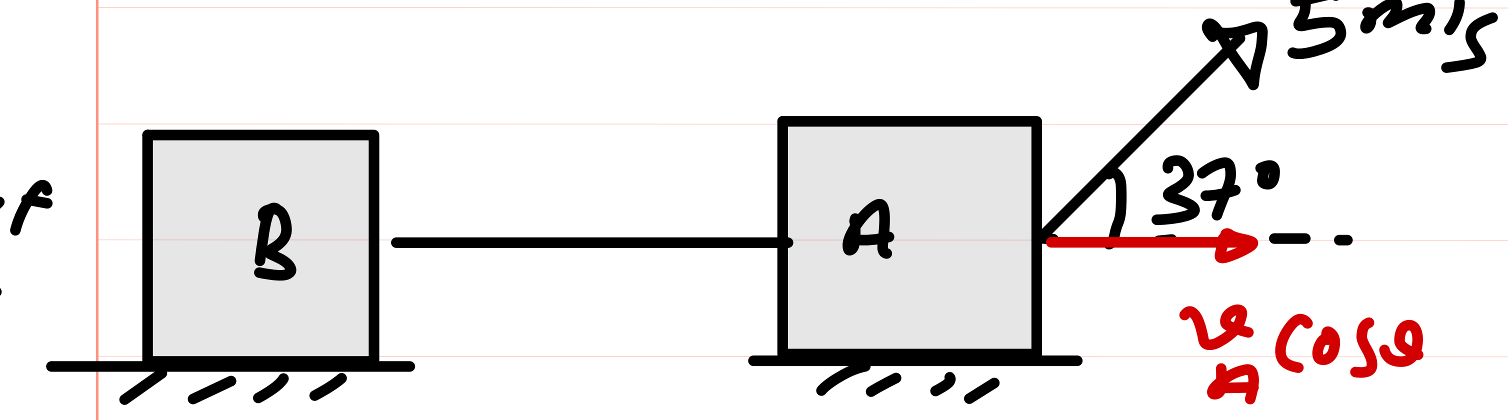
$v_B = 5\,m/s$

Ex



$v_B = 5\,m/s$

Ex



$V_B = ??$

$V_B = V_A \cos\theta$

$= 5\cos 37$

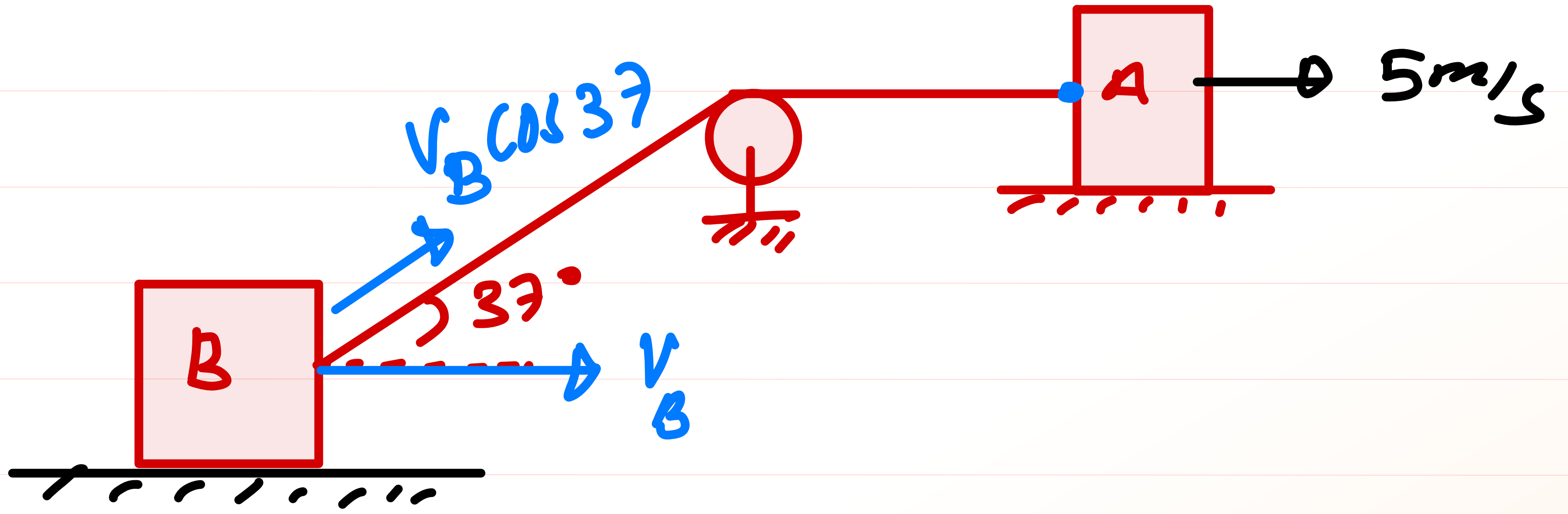
$\boxed{V_B = 4\,m/s}$

Concept: Relative velocity (of connected objects with string) is zero along string

$$\boxed{(v_{AB})_{\parallel} = 0 \Rightarrow (v_A)_{\parallel} = (v_B)_{\parallel}}$$

means both connected object have equal velocity along connected string

Ex



$v_B = ??$

$V_B \cos(37) = V_A$

$V_B \times \frac{4}{5} = 5 \Rightarrow \boxed{V_B = \frac{25}{4}\,m/s}$ Ans

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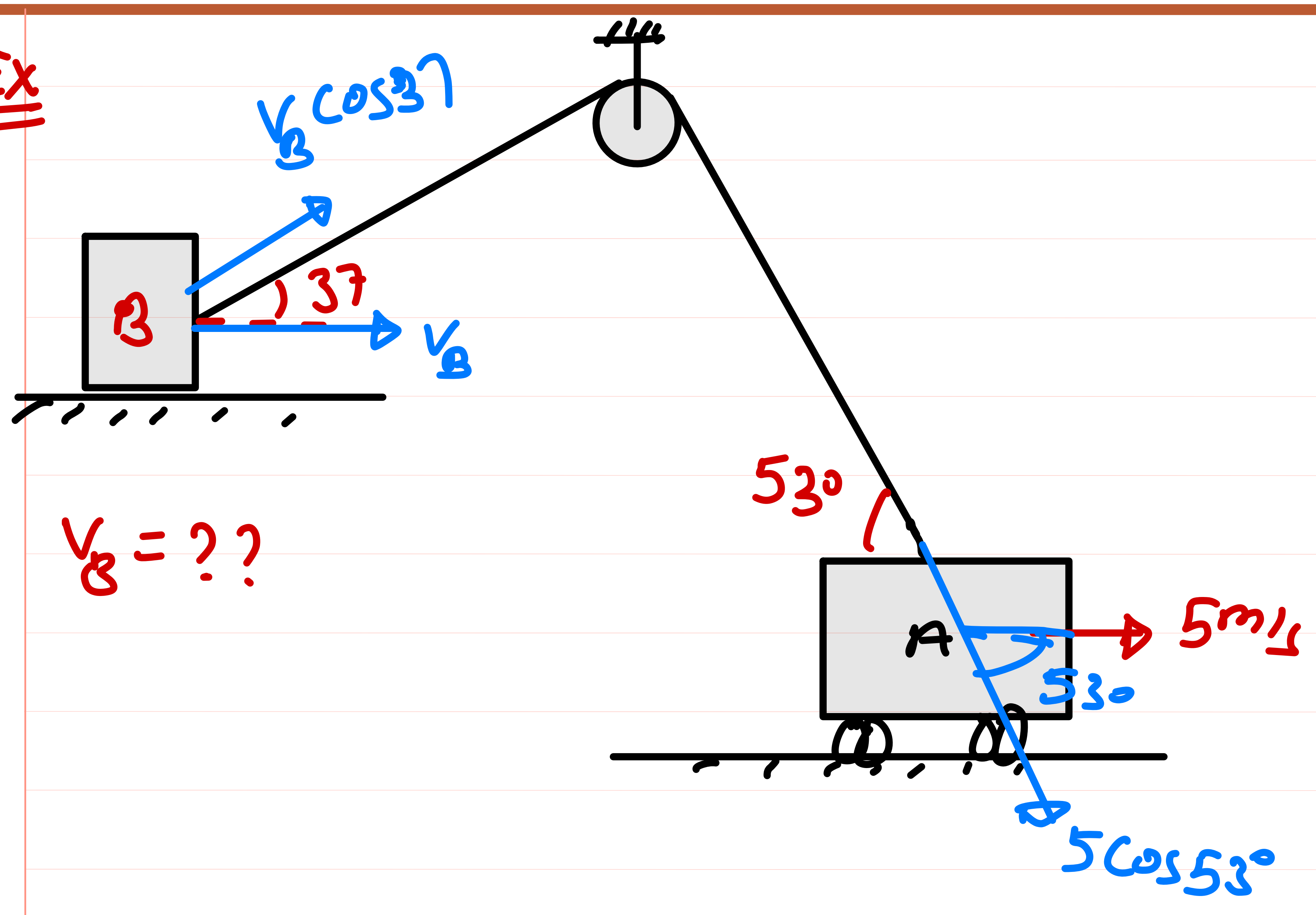
Ex



$V_B = ??$

$V_B \cos 37 = 5 \cos 53$

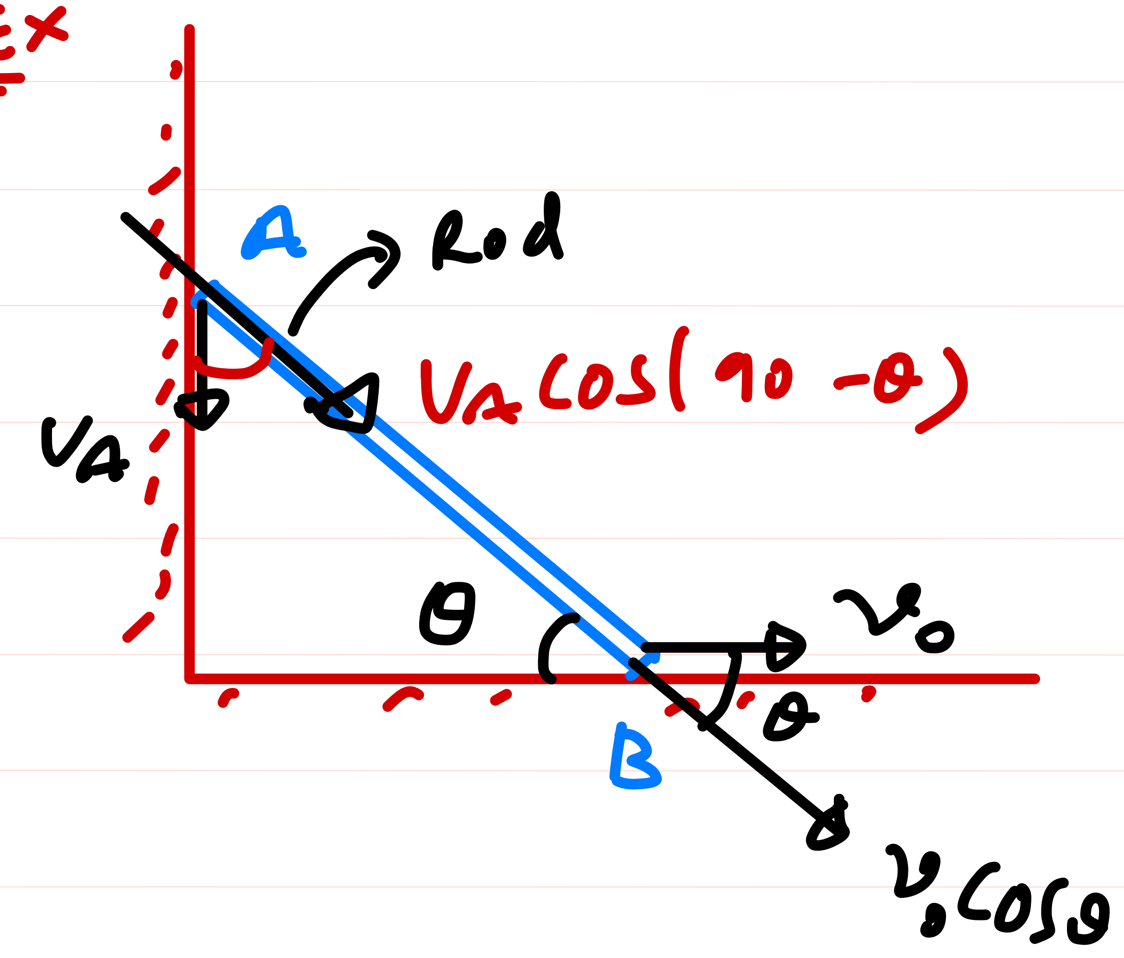
$V_B \times \frac{4}{\cancel{5}} = 5 \times \frac{3}{\cancel{5}}$

$\boxed{V_B = \frac{15}{4} \text{ m/s}}$ Ans

Ex

velocity of end A

(All surfaces are smooth)

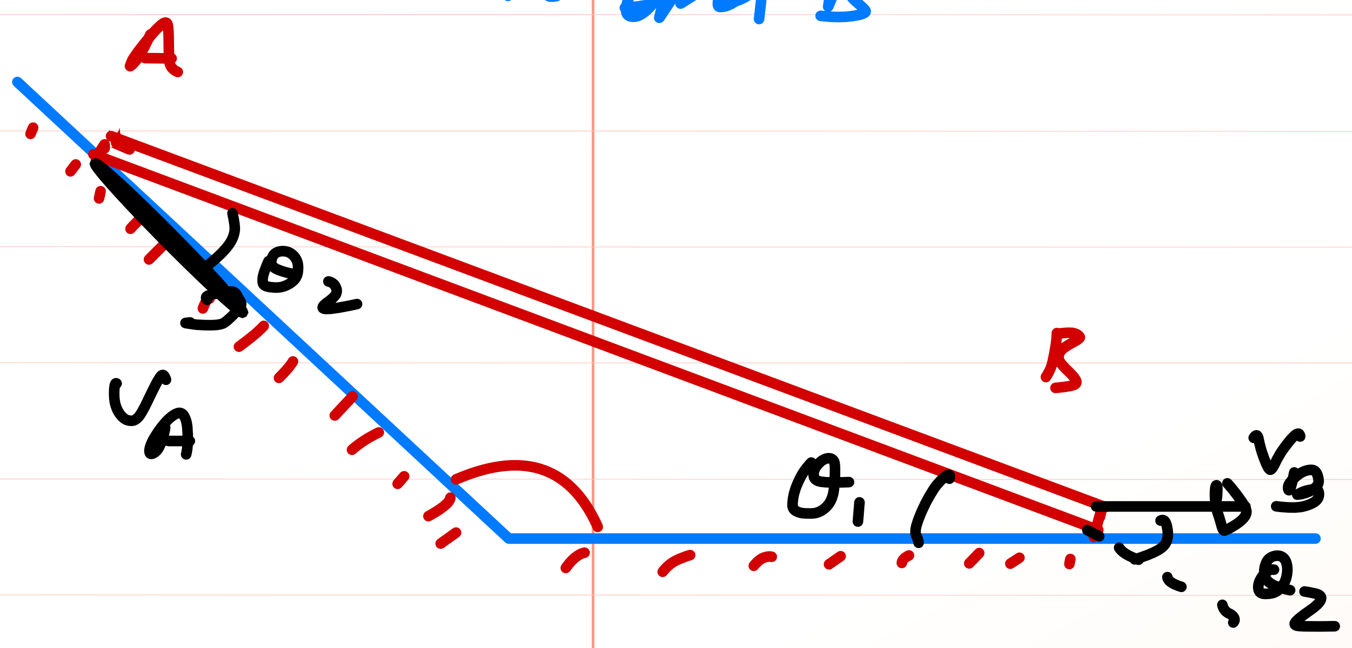


$V_A \cos(90-\theta) = v_0 \cos\theta$

$V_A = \frac{v_0 \cos\theta}{\sin\theta}$

$\boxed{V_A = v_0 \cot\theta}$ Ans

Ex Reln b/w velocities of end A and B



$\boxed{V_B \cos\theta_1 = V_A \cos\theta_2}$

Ans