Illustration 9 to 11.

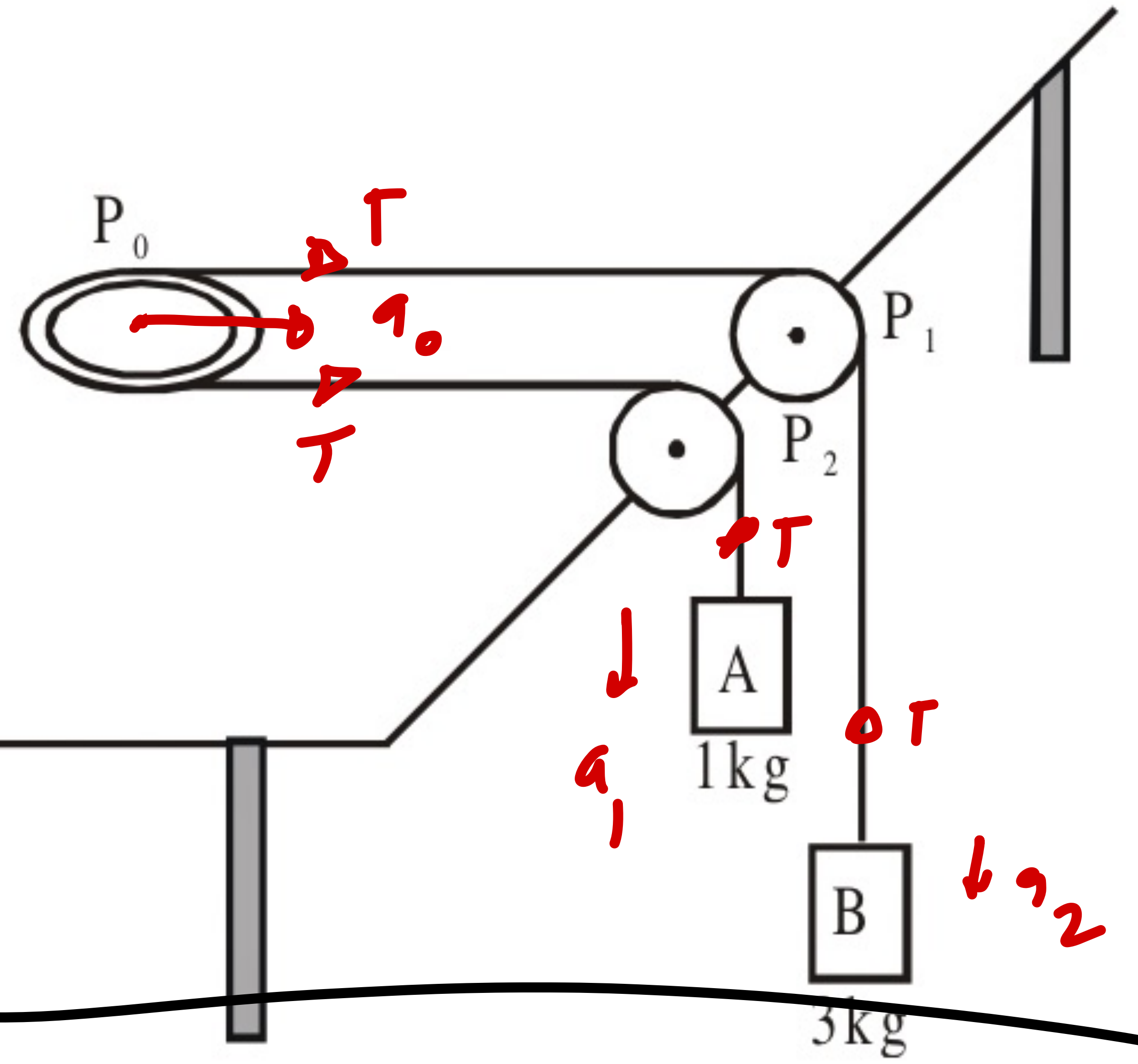
A smooth pulley P_0 of mass 2 kg is lying on a smooth table. A light string passes round the pulley and has masses 1 kg and 3kg attached to its ends. The two portions of the string being perpendicular to the edge of the table so that the masses hang vertically. Pulleys P_1 and P_2 are of negligible mass. [$g=10m/s^2$]

For Pulley

$2T = M_P a_0$

$2T = 2a_0$

$T = a_0$ — ①



$a_0 = \frac{a_1+a_2}{2}$

$2a_0 = a_1+a_2$ — ①

9. Tension in string is

(A) 12 N (B) 6 N (C) 24 N (D) 18 N

For - A

$1g - T = 1\times a_1$

$g - T = a_1$ — ③

For - B

$3g - T = 3a_2$

$g - T/3 = a_2$ — ④

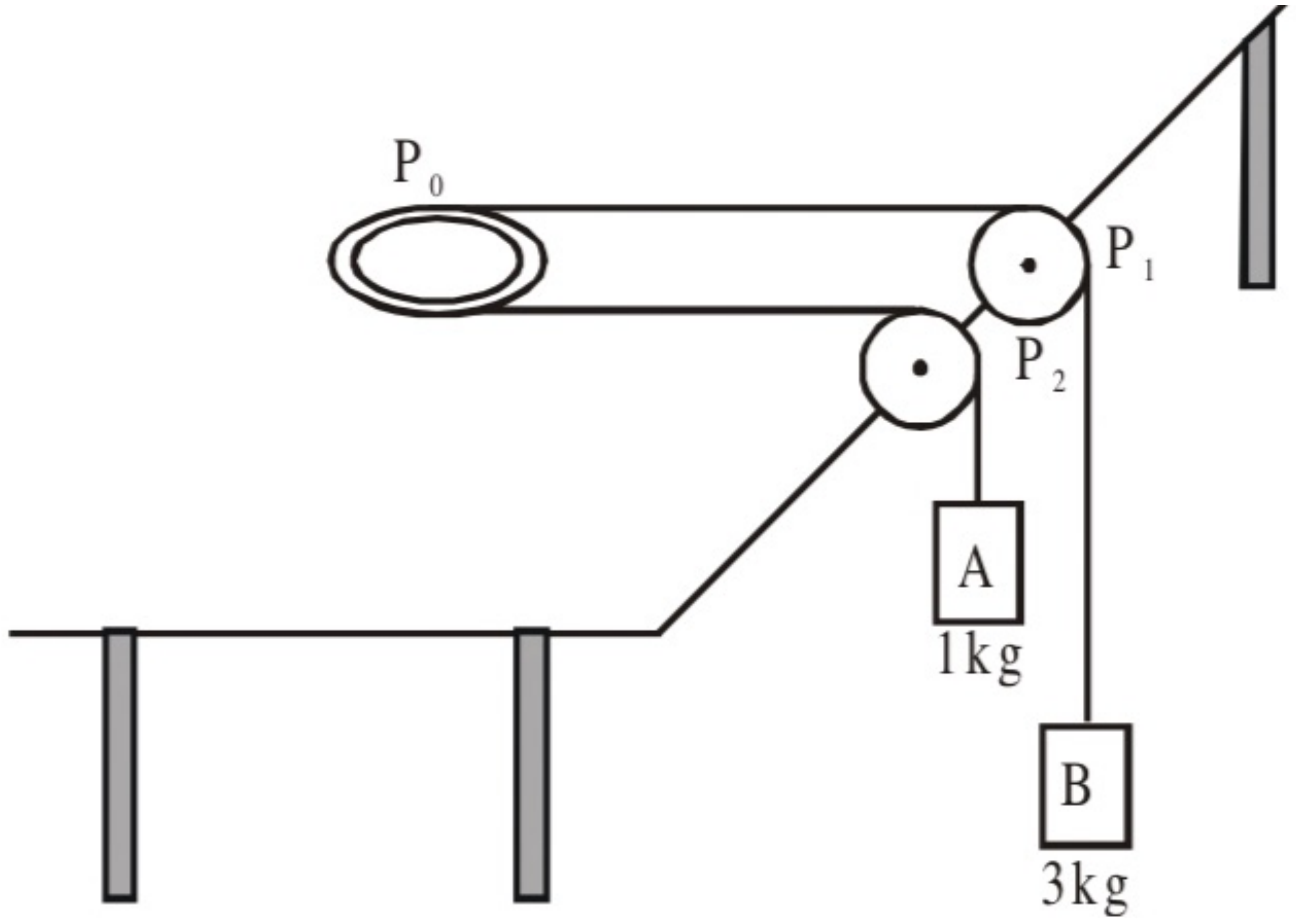
Add eq ③ + ④

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

$2g - 4T/3 = 2a_0$

$2g - \frac{4a_0}{3} = 2a_0$

$2g = 2a_0 + \frac{4a_0}{3}$



10. Acceleration of pulley P_0 is

(A) 2 m/s^2 (B) 4 m/s^2 (C) 3 m/s^2 (D) 6 m/s^2

11. Acceleration of block A is

(A) 6 m/s^2 (B) 4 m/s^2 (C) 3 m/s^2 (D) 8 m/s^2

$g - T = a_1$

$10 - 6 = a_1$

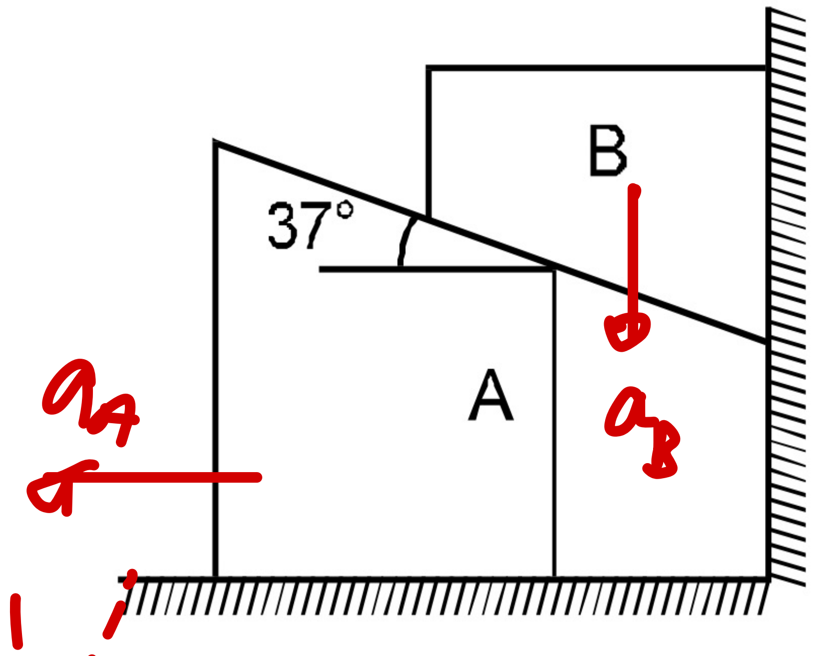
$\boxed{4\ m/s^2 = a_1}$

$2g = \frac{10a_0}{3}$

$\boxed{6\ m/s^2 = a_0}$

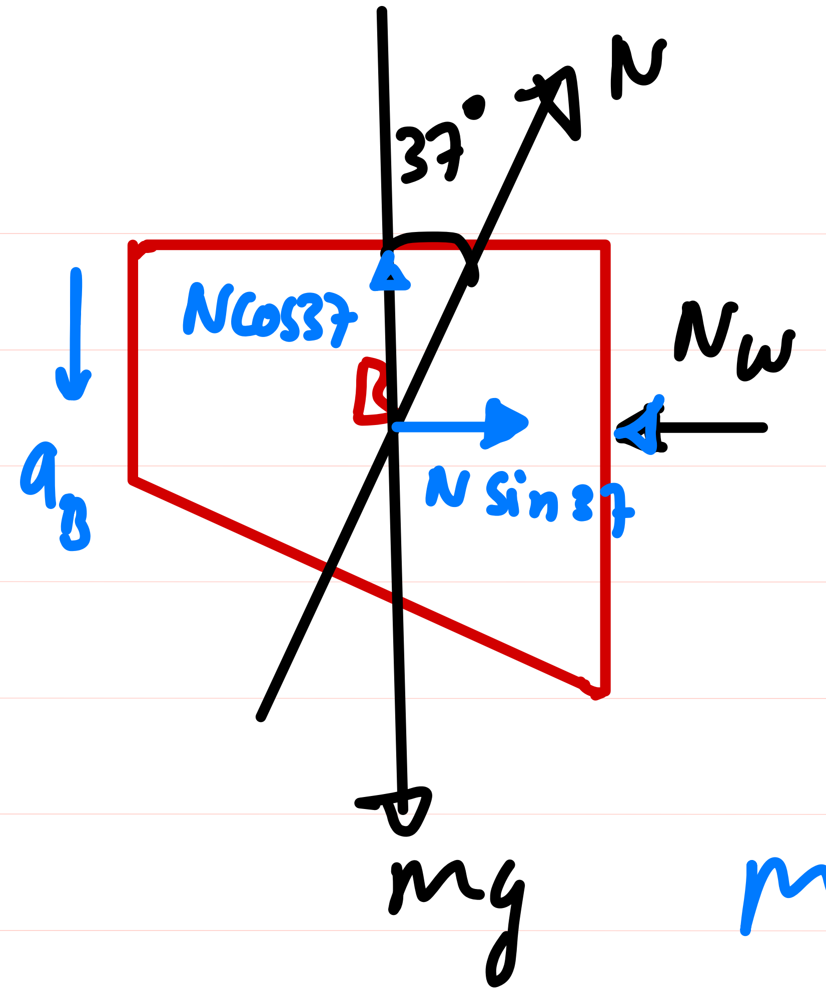
$\boxed{T = 6\ N}$

8. The masses of blocks A and B are same and equal to m. Friction is absent everywhere. Find the magnitude of normal force with which block B presses on the wall and accelerations of the blocks A and B.



$$\boxed{a_B = a_A \tan\theta}$$

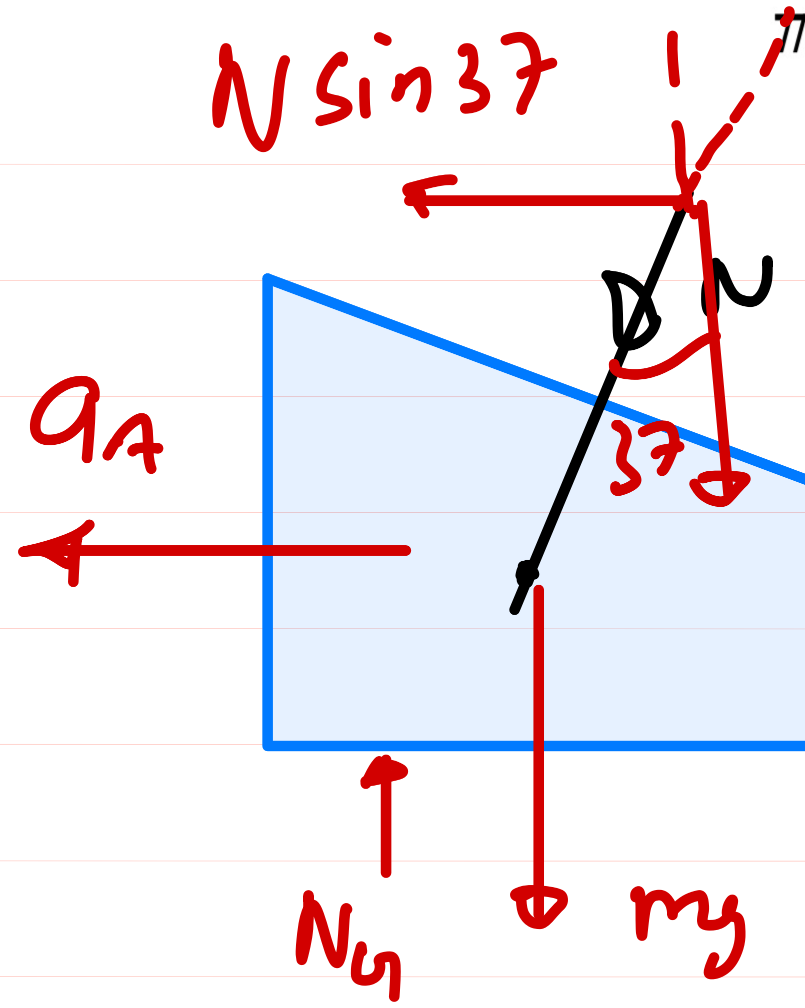
$$a_B = \frac{3a_A}{4}$$



$N_w = N\sin 37$

$N_w = \frac{3N}{5}$

$mg - N\cos 37 = ma_B$



$N\sin 37 = ma_A$

$\frac{3N}{5} = ma_A$

$$\boxed{N = \frac{5}{3}ma_A} \quad (2)$$

$mg - \frac{4N}{5} = ma_B \quad (1)$

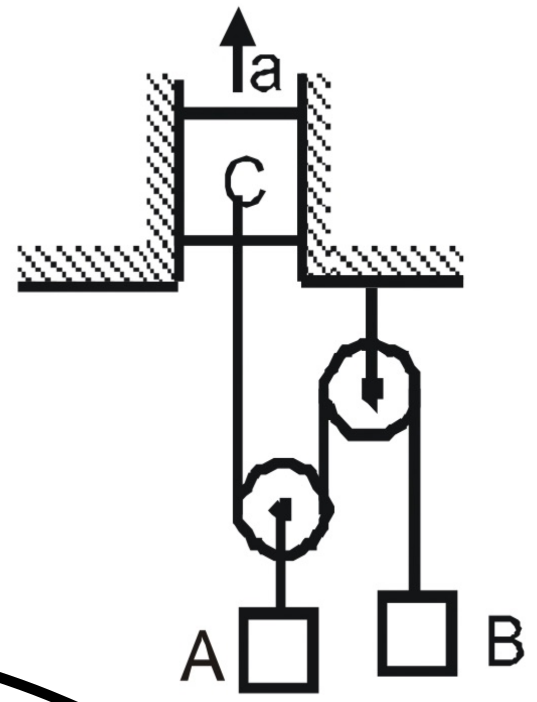
$mg - \frac{4}{5}\times\frac{5}{3}ma_A = ma_B$

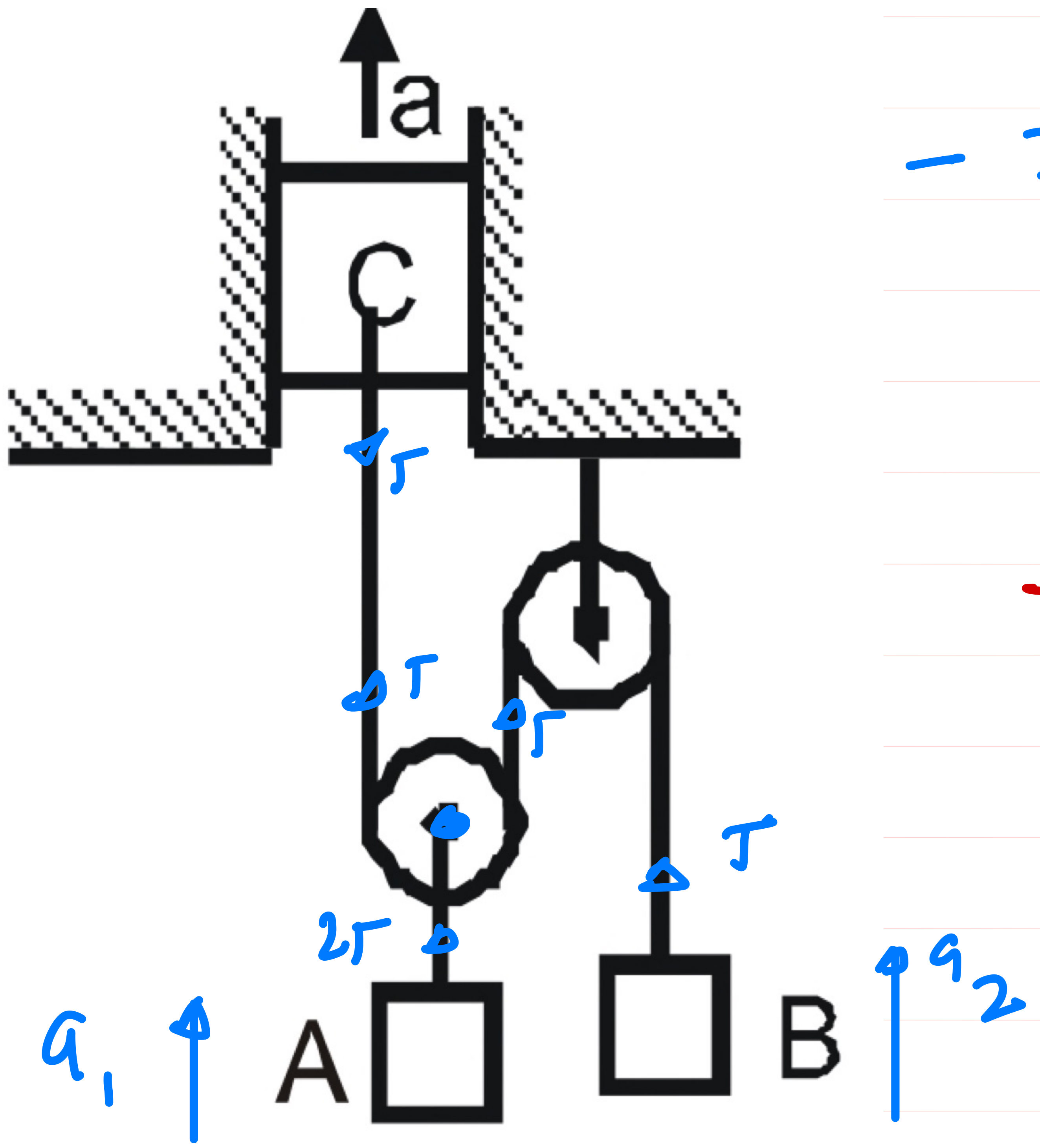
$mg = \frac{4}{3}ma_A + ma_B$

$g = \frac{4}{3}a_A + \frac{3}{4}a_A$

$g = \frac{25}{12}a_A \Rightarrow \boxed{a_A = \frac{12g}{25}}$

9*. The block C shown in the figure is ascending with an acceleration $a = 3\ m/s^2$ by means of some motor not shown here. Find the acceleration of the bodies A and B of masses 10 kg and 5 kg, respectively, assuming that pulleys are massless and friction is absent everywhere.





$$-Ta + 2Ta_1 + Ta_2 = 0$$

$$a = 2a_1 + a_2 \quad \text{— (1)}$$

FOR - A

$$2T - m_A g = m_A a_1$$

$$2T - 100 = 10a_1$$

$$T - 50 = 5a_1 \quad \text{— (2)}$$

FOR - B

$$T - m_B g = m_B a_B$$

$$T - 50 = 5a_2 \quad \text{— (3)}$$

From Eq (1) & (2)

$$a_1 = a_2$$

$$a = 2a_1 + a_1$$

$$\boxed{a_1 = a/3 = a_2}$$

$$\boxed{a_1 = a_2 = 1\ m/s^2}$$

Ans

2. A particle of mass m is moving in a straight line with momentum p. Starting at time t = 0, a force F = kt acts in the same direction on the moving particle during time interval T so that its momentum changes from p to 3p. Here k is a constant. The value of T is : ***[JEE-MAIN-2019]***

(A) $2\sqrt{\frac{p}{k}}$ (B) $\sqrt{\frac{2p}{k}}$ (C) $\sqrt{\frac{2k}{p}}$ (D) $2\sqrt{\frac{k}{p}}$

$$\frac{dp}{dt} = F$$

$$dp = F\,dt$$

$$\int_p^{3p} dp = k\int_0^t t\,dt$$

$$3p - p = k\frac{t^2}{2}$$

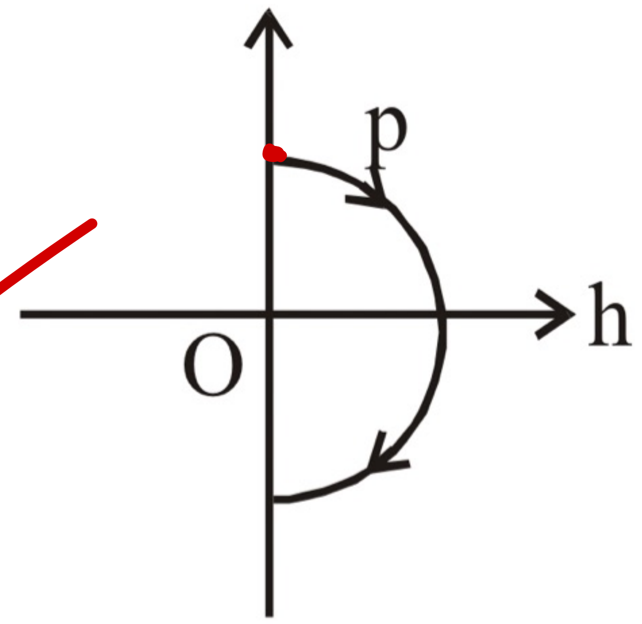
$$2p = \frac{k}{2}t^2$$

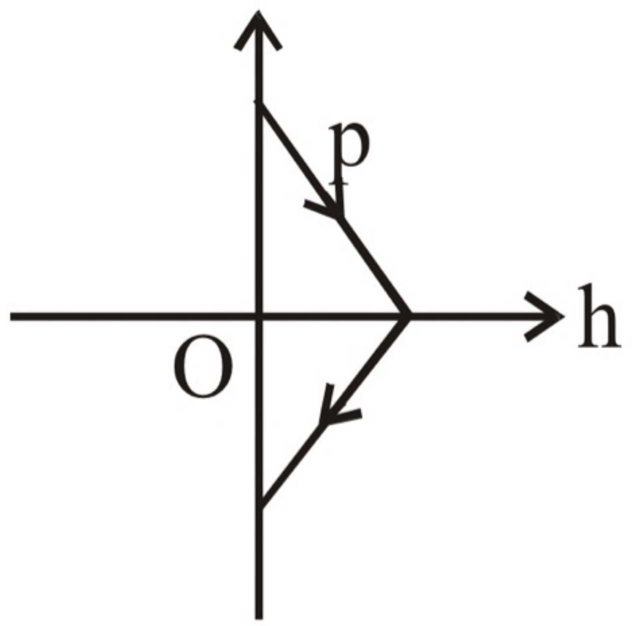
$$t = \sqrt{\frac{4p}{k}}$$

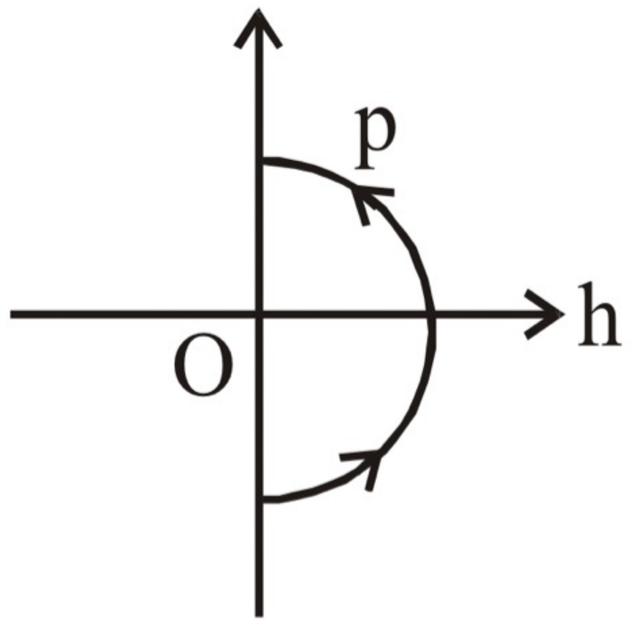
$$T = 2\sqrt{\frac{p}{k}}$$

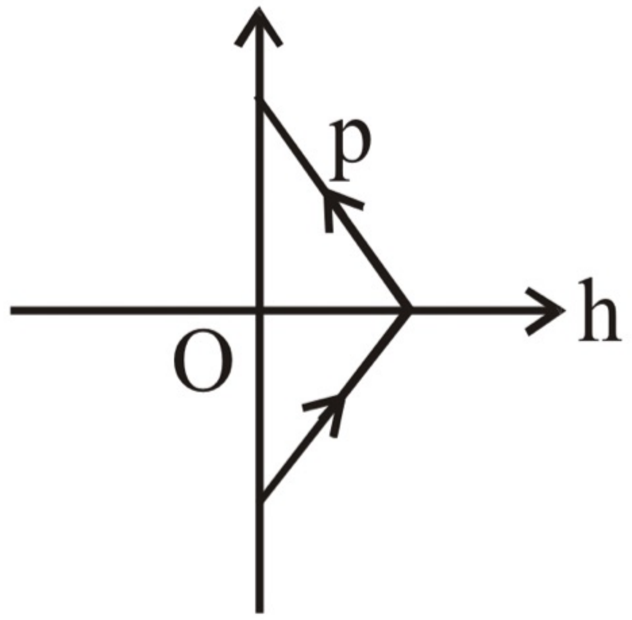
3. A ball is thrown vertically up (taken as +z-axis) from the ground. The correct momentum-height (p-h) diagram is :

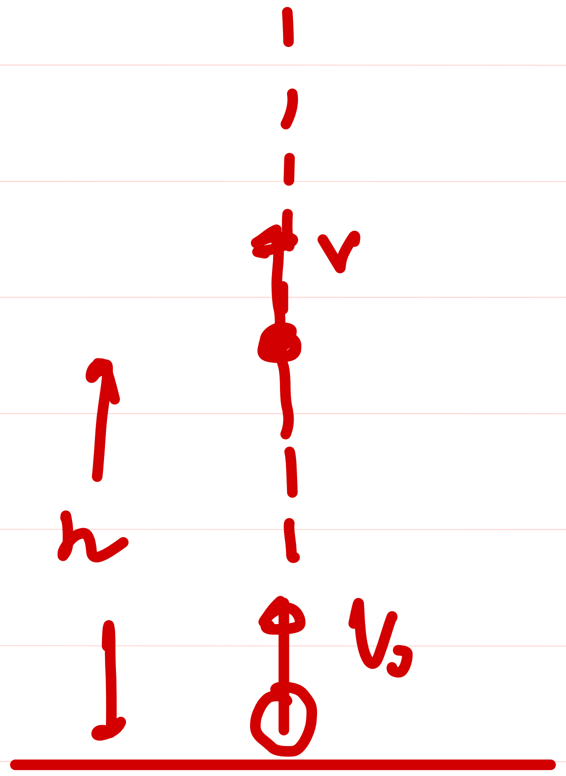
[JEE-MAIN-2019]

(A)


(B)


(C)


(D)




$$p = mv$$

$$p = m\sqrt{v_0^2 - 2gh}$$

$$\frac{p^2}{m^2} = v_0^2 - 2gh$$

$$p^2 = (mv_0)^2 - 2m^2 g h$$

4. A spring whose unstretched length is l has a force constant k. The spring is cut into two pieces of unstretched lengths l_1 and l_2 where, $l_1 = nl_2$ and n is an integer. The ratio k_1/k_2 of the corresponding force constants, k_1 and k_2 will be : **[JEE-MAIN-2019]**

(A) $\frac{1}{n^2}$ (B) n^2 ~~(C)~~ $\cancel{\frac{1}{n}}$ (D) n

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

$K = \frac{C}{l}$ — ①

$l_1 = \frac{C}{k_1}$ $l_2 = \frac{C}{k_2}$

$\frac{l_2}{l_1} = \frac{k_1}{k_2}$

$\frac{1}{n} = \frac{k_1}{k_2}$

$l_1 = \frac{nl}{(n+1)}$

$\frac{(n+1)}{n}\left(\frac{C}{l}\right) = \frac{C}{l_1}$

$\frac{(n+1)}{n} K = k_1$ — ②

$l_1 + l_2 = l$

$nl_2 + l_2 = l$

$l_2 = \frac{l}{(n+1)}$

$(n+1)\frac{C}{l} = \frac{C}{l_2}$

$(n+1) K = k_2$ — ①

3. A particle moves in the X-Y plane under the influence of a force such that its linear momentum is $\vec{p}(t) = A[\hat{i}\cos(kt) - \hat{j}\sin(kt)]$, where A and k are constants. The angle between the force and the momentum is **[IIT JEE 2007]**

(A) 0° (B) 30° (C) 45° (D) 90° ✓

$\vec{P} = A(\cos(kt)\hat{i} - \sin(kt)\hat{j})$

$\vec{F} = \frac{d\vec{P}}{dt} = A[-\sin(kt) \cdot k\hat{i} - \cos(kt) \cdot k\hat{j}]$

$\vec{F} = -kA[\sin(kt)\hat{i} + \cos(kt)\hat{j}]$

$\vec{P} \cdot \vec{F} = PF\cos\theta$

$-kA^2[\cancel{(\sin kt \cos kt)} - \cancel{(\cos kt)\sin kt}] = PF\cos\theta$

$0 = PF\cos\theta \Rightarrow \cos\theta = 0 \Rightarrow \theta = 90°$

Dot product of 2-vectors

$\vec{a} = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$

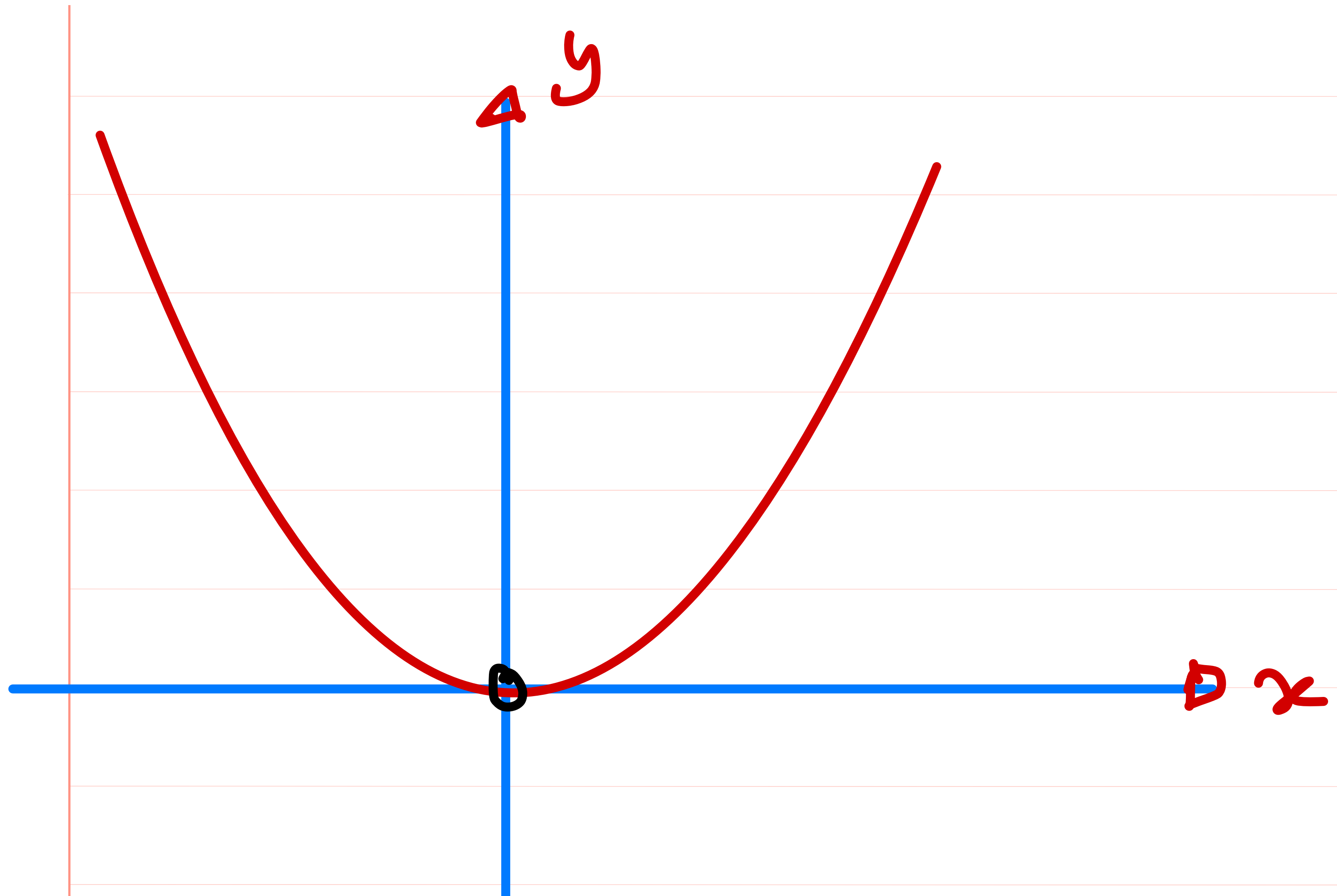
$\vec{b} = a_2\hat{i} + b_2\hat{j} + c_2\hat{k}$

$\vec{a} \cdot \vec{b} = ab\cos\theta$

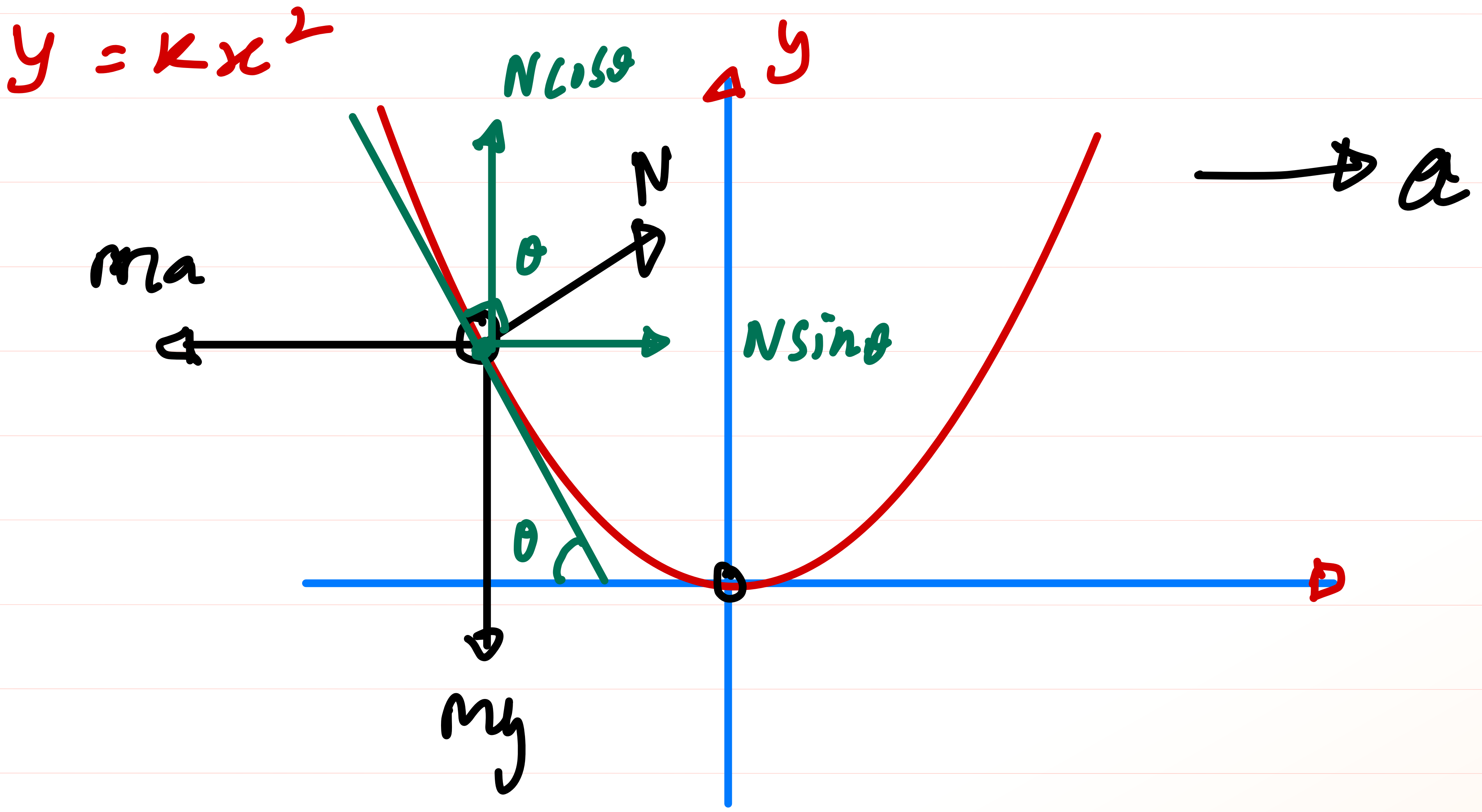
$\vec{a} \cdot \vec{b} = a_1a_2 + b_1b_2 + c_1c_2$

4. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is : ***[IIT-JEE 2009]***

(A) $\dfrac{a}{gk}$ (B) $\dfrac{a}{2gk}$ (C) $\dfrac{2a}{gk}$ (D) $\dfrac{a}{4gk}$



Initial



$$\frac{N\sin\theta = ma}{N\cos\theta = mg}$$

$a = g\tan\theta$

$\tan\theta = \text{slope} = \dfrac{dy}{dx}$

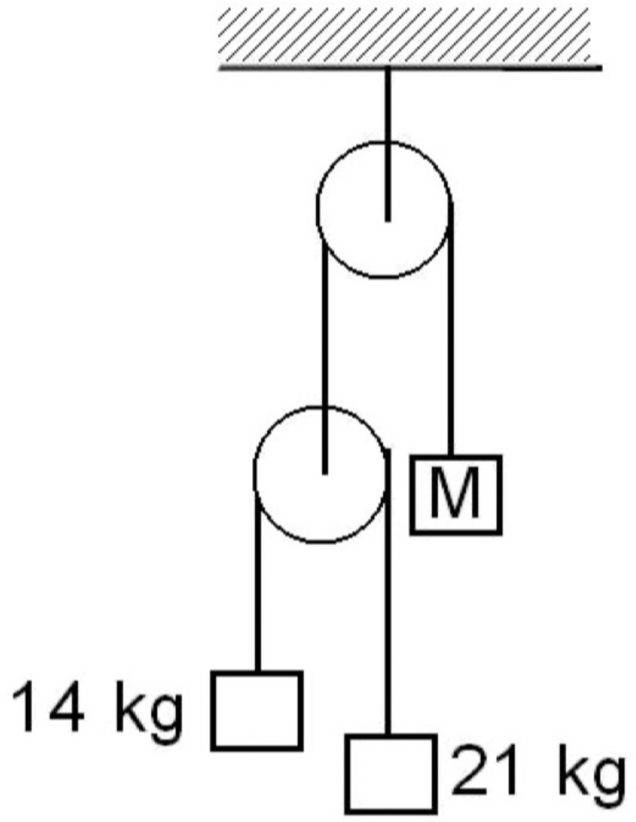
$y = kx^2$

$\dfrac{dy}{dx} = 2kx$

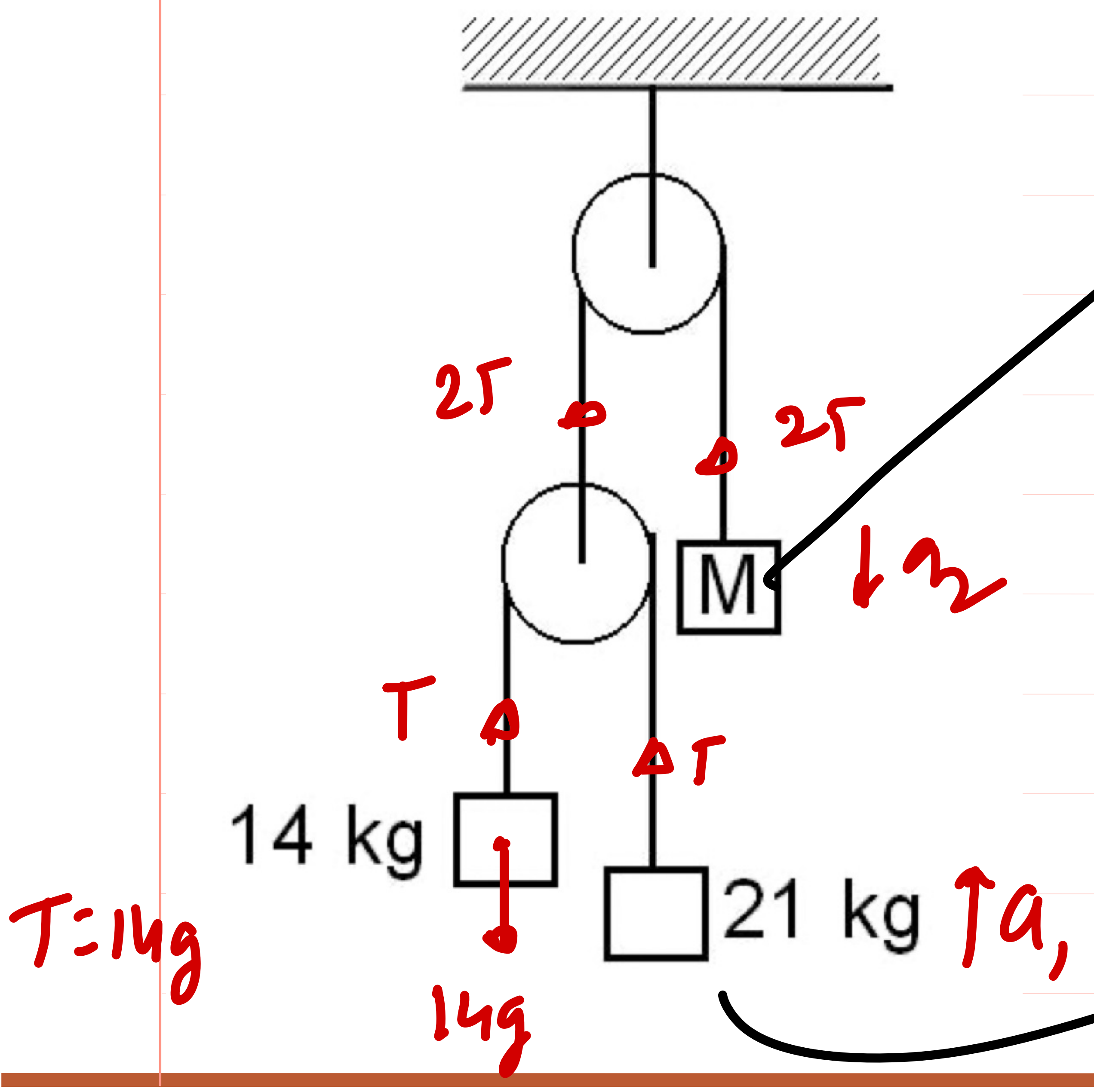
$a = g \times 2kx$

$$\boxed{x = \frac{a}{2gk}}$$

10. In the system of pulleys , the value of M such that 14 kg block remains at rest is :



(A) 28 kg (B) 35 kg (C) 24 kg (D) 42 kg



$Ta_1 - 2Ta_2 = 0$

$\boxed{a_1 = 2a_2}$

$T - 21g = 21a_1$ —(1)

$Mg - 2T = Ma_2$ —(2)

(1) × 2 + (2)

$\cancel{2T} - 41g = 41a_1$

$Mg - \cancel{2T} = Ma_2$

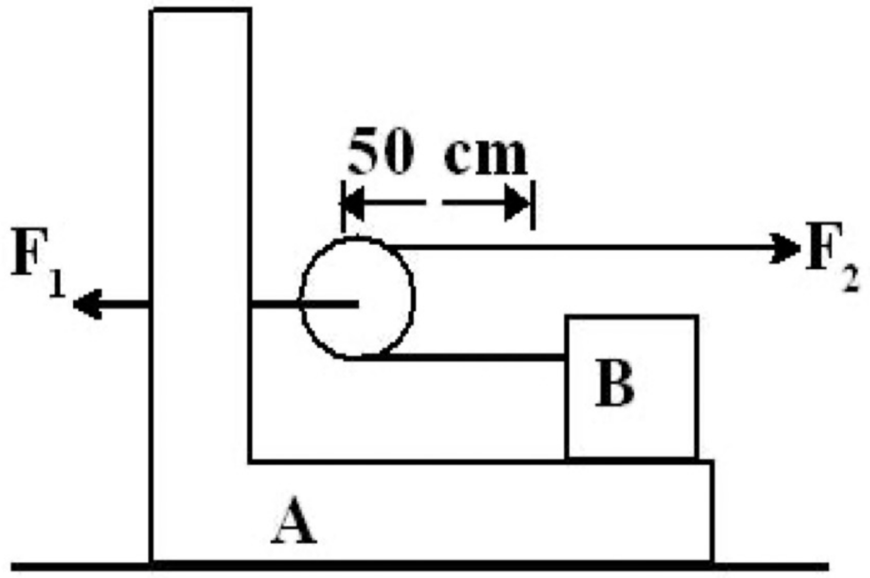
$Mg - 41g = 41a_1 + Ma_2$

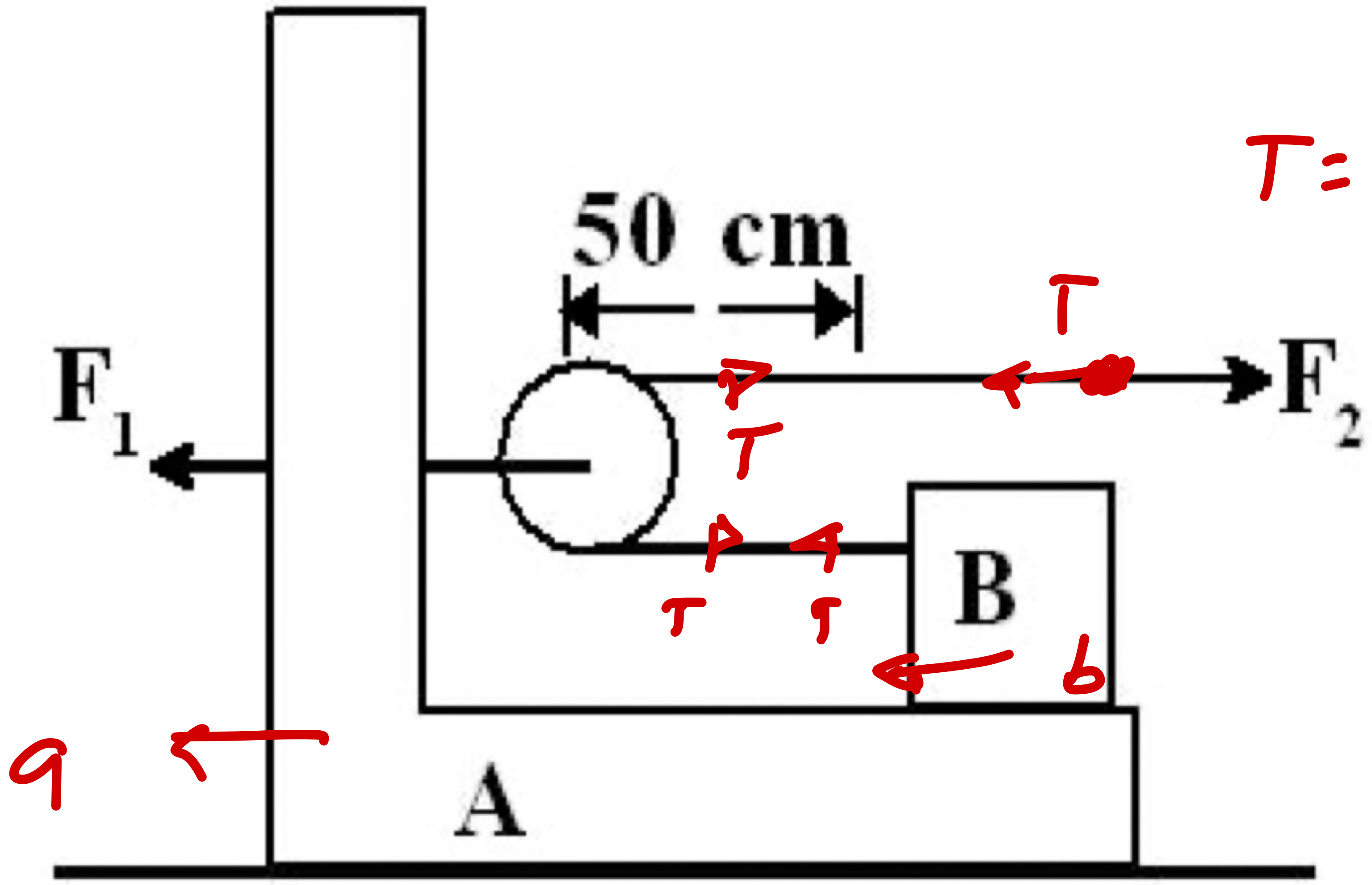
$Mg - 41g = 41 \times 2a_2 + Ma_2$

$Mg - 41g = (82 + M)a_2$

$\left(\frac{M - 41}{M + 82}\right) g = a_2$

11. A 1 kg block 'B' rests as shown on a bracket 'A' of same mass . Constant forces $F_1 = 20$ N and $F_2 = 8$ N start to act at time t = 0 when the distance of block B from pulley is 50 cm . Time when block B reaches the pulley is





For - A

$T = F_2$

$F_1 - 2T = m_A a$

$20 - 2T = 1a$

For - B

$T = 1b$

$F_2 = b$

$8 = b$

$\boxed{b = 8\ m/s^2}$

$20 - 2 \times 8 = a$

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

$a_{BA} = 8 - 4 = 4$

$50 \times 10^{-2} = \frac{1}{2} \times 4 \times t^2$

$t = \sqrt{\frac{100}{4} \times 10^{-2}} = 5 \times 10^{-1}$

$= 0.5$ sec.