Physicsaholics

DPP – 1(Friction)

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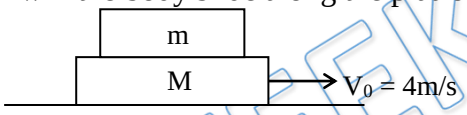
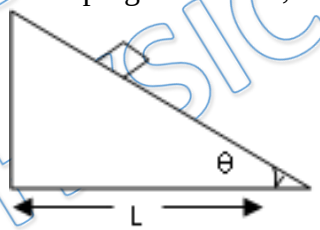
Q 1. A body is moving down inclined plane of slope 37°. The coefficient of friction between the body and plane varies as μ = 0.3 x, where x is distance traveled down the plane. The body will have maximum speed at –
(sin 37° = $\frac{3}{5}$ and g = 10 m/s^2)
(a) x = 1.16 m (b) x = 2 m
(c) bottom of plane (d) x = 2.5 m

Q 2. A stationary body of mass m is slowly lowered (zero initial velocity) onto a long massive platform of mass M (M>>m) moving at a speed V_0 = 4 m/s as shown in fig. How far will the body slide along the platform? (μ = 0.2 and g = 10 m/s^2)



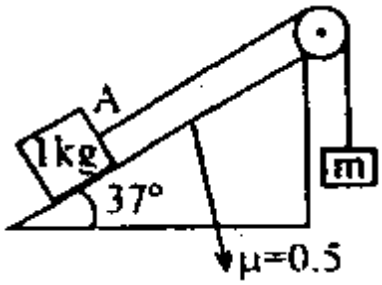
(a) 4 m (b) 6 m
(c) 12 m (d) 8 m

Q 3. A small body starts sliding down an inclined plane of inclination θ, whose base length is equal to L. The coefficient of friction between the body and the surface is μ. If the angle θ is varied keeping L constant, at what angle will the time of sliding be least?



(a) $tan^{-1}\left(\frac{1}{\mu}\right)$ (b) $tan^{-1}\left(\frac{-1}{\mu}\right)$
(c) $\frac{1}{2}tan^{-1}\left(\frac{1}{\mu}\right)$ (d) $\frac{1}{2}tan^{-1}\left(\frac{-1}{\mu}\right)$

Q 4. In the figure, what should be mass m so that block A slide up with a constant velocity?



(a) 2 Kg (b) 1 Kg
(c) 4 Kg (d) 2.5 Kg

Q 5. In the diagram shown in figure. Match the following table

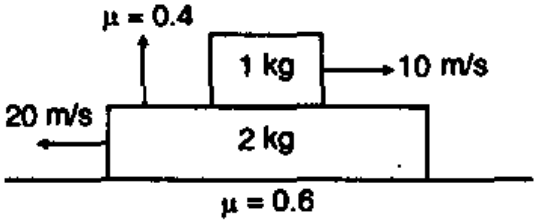
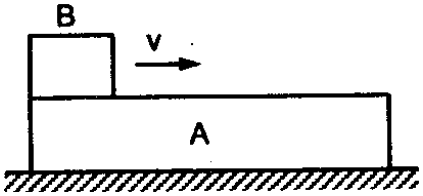


Table-1		Table-2	
(A)	Absolute acceleration of 1 kg block	(P)	11 m/s^2
(B)	Absolute acceleration of 2 kg block	(Q)	6 m/s^2
(C)	Relative acceleration between the two	(R)	17 m/s^2
		(S)	None

Q 6. A block of mass 4 kg is kept over a rough horizontal surface. The coefficient of friction between the block and the surface is 0.1. At $t = 0$, velocity 3 m/s $\hat{\imath}$ is imparted to the block and simultaneously force 2N ($-\hat{\imath}$) starts acting on it. Its displacement in first 5 second is

(a) $8\hat{\imath}$ (b) $-8\hat{\imath}$
(c) $3\hat{\imath}$ (d) $-3\hat{\imath}$

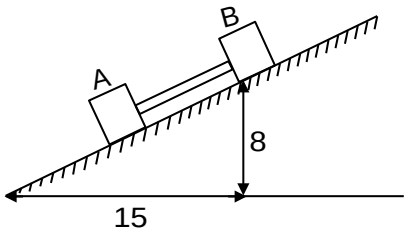
Q 7. A long block A is at rest on a smooth horizontal surface. A small block B, whose mass is half of A, is placed on A at one end and projected along A with some velocity u. The coefficient of friction between the blocks is μ.



(a) The blocks will reach a final common velocity u/3
(b) Friction on A is towards right.

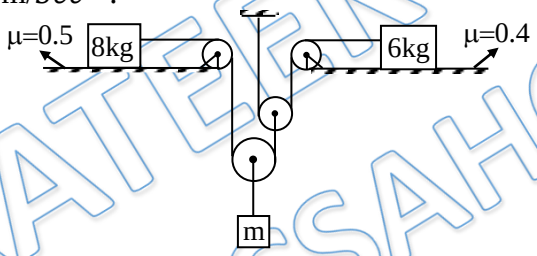
(c) Before the blocks reach a common velocity, the acceleration of A relative to B is $\frac{2}{3}\mu g$.
(d) Before the blocks reach a common velocity the acceleration of A relative to B is $\frac{3}{2}\mu g$.

Q 8. Blocks *A* and *B* in the figure are connected by a bar of negligible weight and they are sliding down due to their weight. If mass of *A* and *B* are 170 kg each and $\mu_A = 0.2$ and $\mu_B = 0.4$, where μ_A and μ_B are the coefficients of friction between blocks and plane, calculate the force in the bar. ($g = 10$ m/s^2).



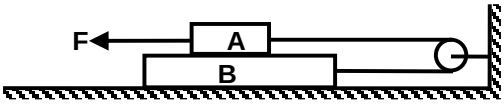
(a) 150 N (b) 75 N
(c) 200 N (d) 250 N

Q 9. 8kg and 6kg blocks are moving towards each other. Find m if it is moving down with acceleration 1 m/Sec^2 ?



(a) 98 Kg (b) 49 Kg
(c) 12 Kg (d) 60 Kg

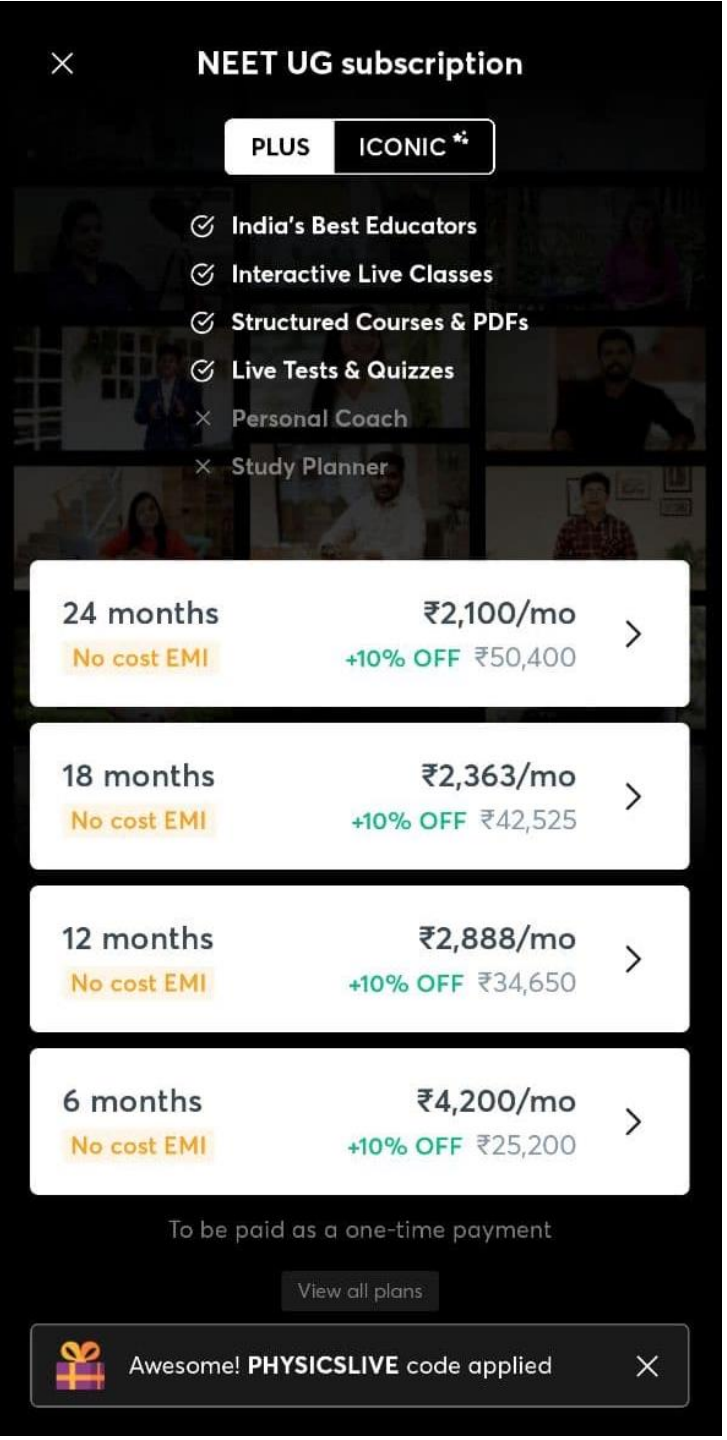
Q 10. In given figure mass of A is 10 kg and that of B is 20 kg. friction coefficient at all surfaces is 0.5. Find F if acceleration of A is 2 m/Sec^2 ?



(a) 150 N (b) 210 N (c) 260 N (d) 310 N

Answer Key

Q.1 d	**Q.2 a**	**Q.3 d**	**Q.4 b**	**Q.5 A(S), B(P), C(S)**
Q.6 c	**Q.7 a, b, d**	**Q.8 a**	**Q.9 c**	**Q.10 d**
Q.11	**Q.12**			



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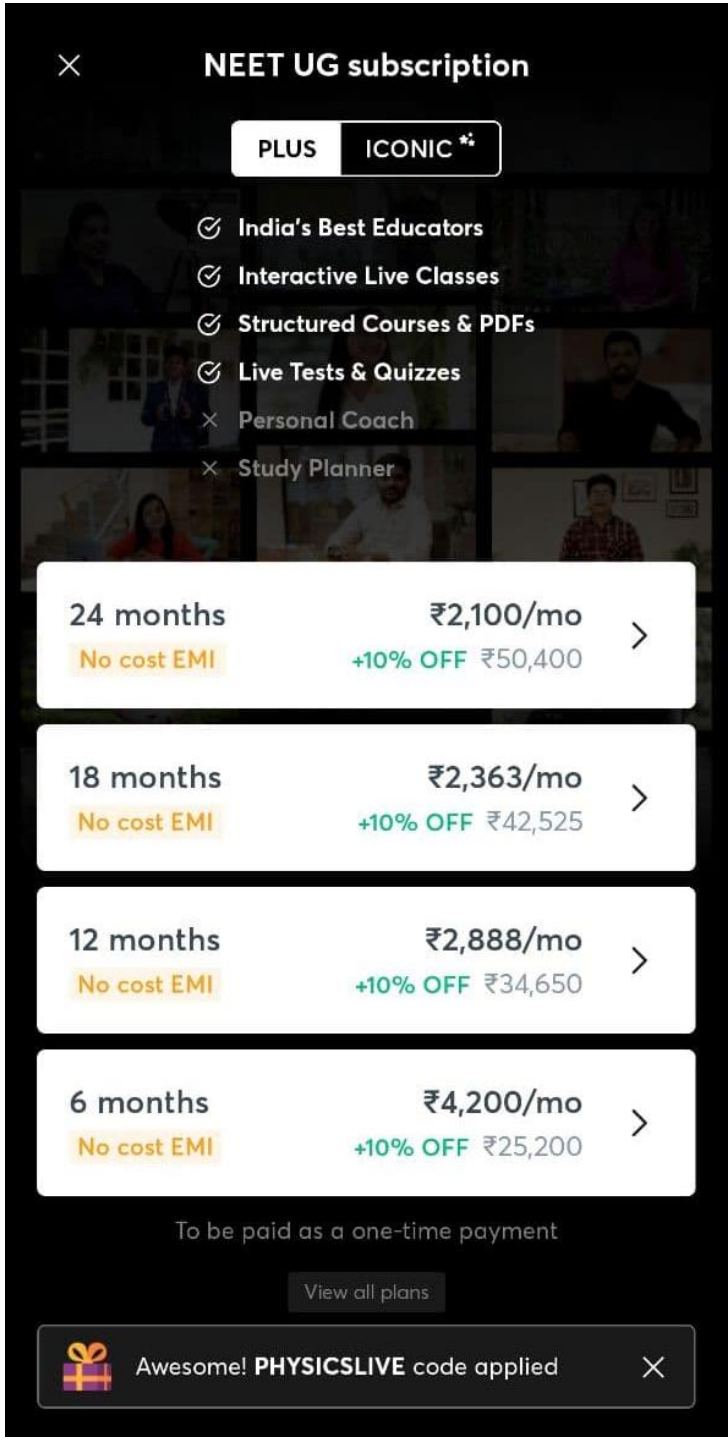


Written Solution

DPP- 1 Friction: Direction of Static & Kinetic Friction & Magnitude of Kinetic Friction

By Physicsaholics Team

Solution.1

from FBD of block, $mg\sin\theta - \mu mg\cos\theta = ma$

acceleration of block at $x = x$

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

at $V = V_{max}$

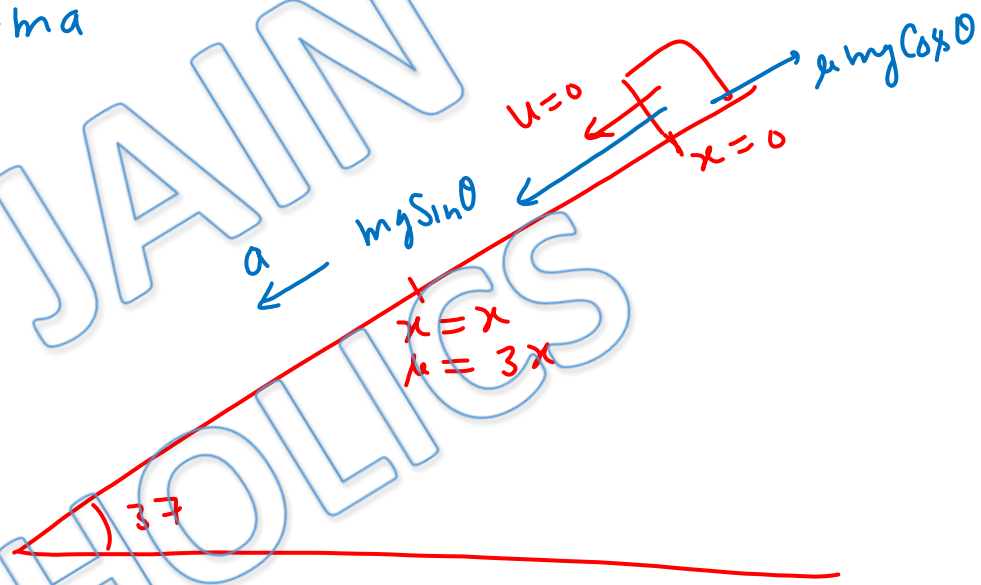
$$\frac{dv}{dx} = 0$$

$$\Rightarrow a = 0$$

$$\Rightarrow \sin\theta = \mu\cos\theta$$

$$\Rightarrow \mu = \tan\theta = 3/4$$

$$\Rightarrow 3x = 3/4 \Rightarrow x = 1/4 = 5/2$$



Ans.d

Solution.2

acceleration of m w.r.t M

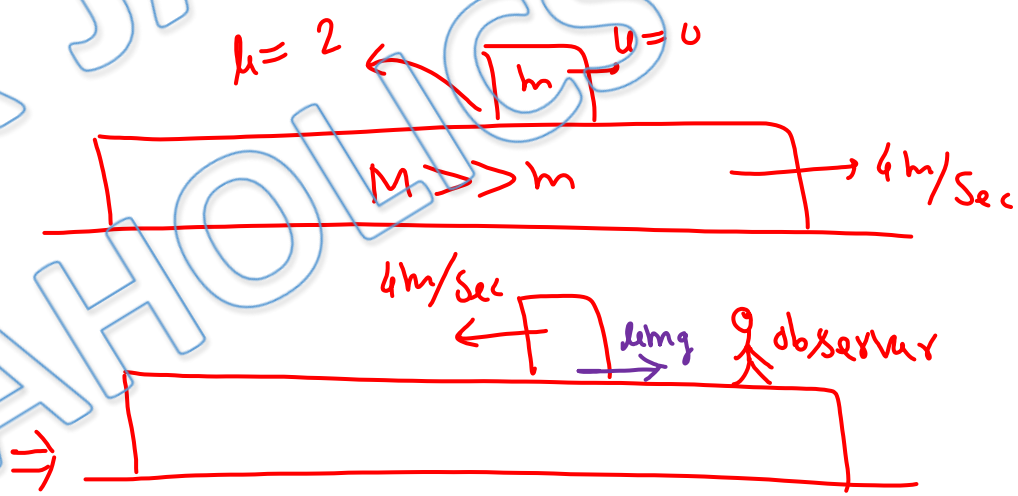
$= \frac{\mu mg}{m} = \mu g = 2\,m/sec^2 \rightarrow$

relative distance covered before Comming to relative rest

$V^2 = u^2 + 2ax$

$0 = 16 - 2 \times 2x$

$x = 4m$



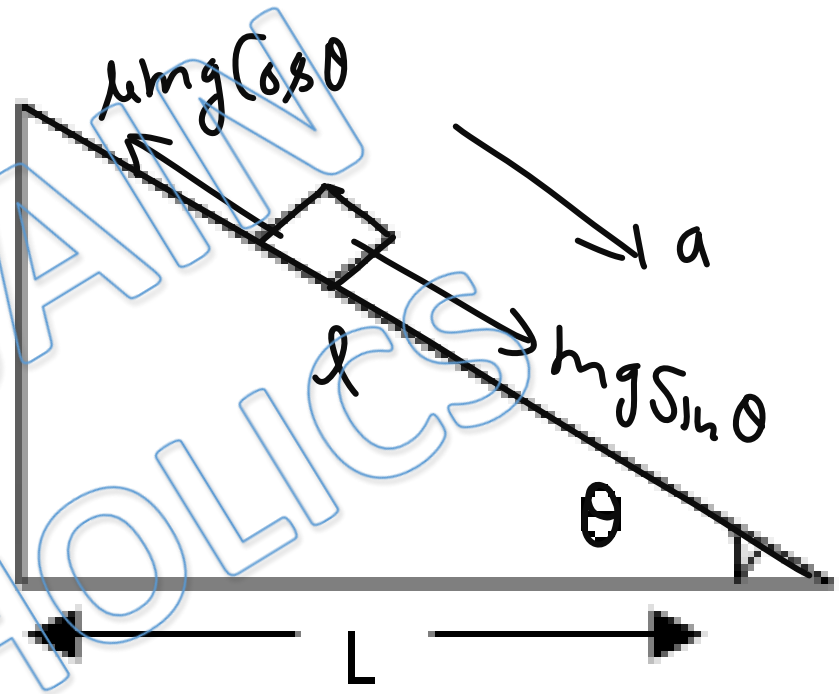
Ans.a

Solution:3

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

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

$$\cos\theta = \frac{L}{l} \Rightarrow l = \frac{L}{\cos\theta}$$



$$l = \frac{1}{2}at^2 \Rightarrow t^2 = \frac{2l}{a} = \frac{2L}{g(\sin\theta - \mu\cos\theta)\cos\theta}$$

$$\Rightarrow t^2 = \frac{2L}{g(\sin\theta\cdot\cos\theta - \mu\cos^2\theta)}$$

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

for minimum time $\left(\frac{1}{2}\sin 2\theta - \mu\cos^2\theta\right)$ should be maximum.

$$\Rightarrow \frac{d}{d\theta}\left[\frac{1}{2}\sin 2\theta - \mu\cos^2\theta\right] = 0$$

$$\Rightarrow \frac{1}{2}\times 2\cos 2\theta - \mu \times 2\cos\theta(-\sin\theta) = 0$$

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

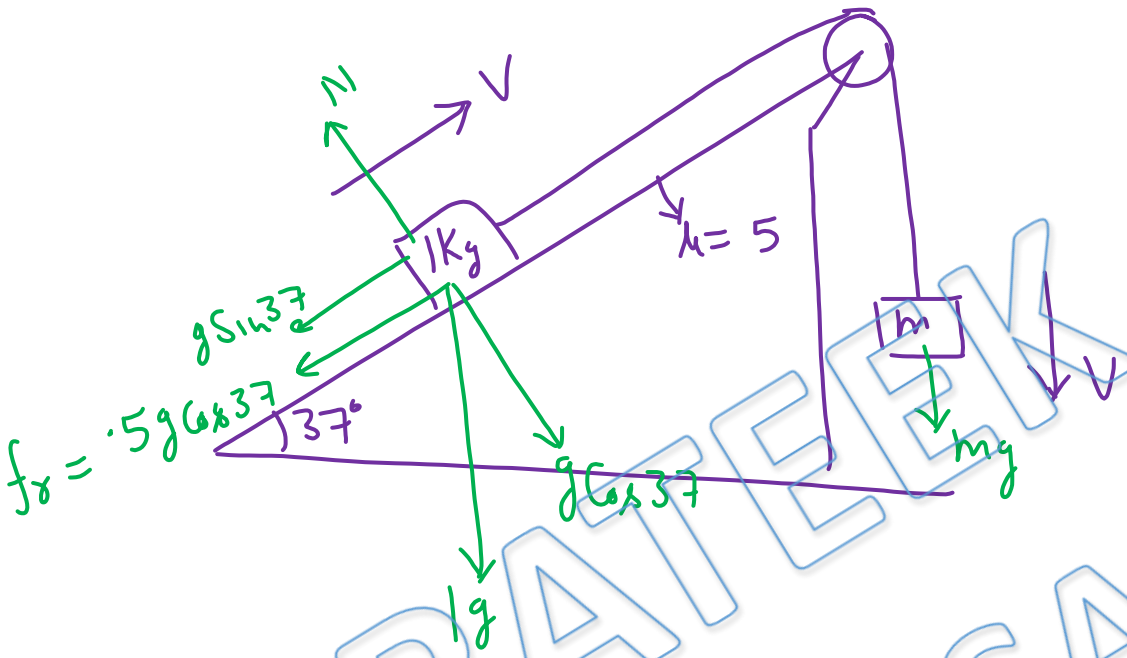
$$\Rightarrow \quad \tan 2\theta = -\frac{1}{\mu}$$

$$\Rightarrow \quad 2\theta = \tan^{-1}\left(-\frac{1}{\mu}\right)$$

$$\Rightarrow \quad \theta = \frac{1}{2}\tan^{-1}\left(-\frac{1}{\mu}\right)$$

Ans (d)

Solution.4



Since $a = 0$

$\Rightarrow$ supporting forces = opposing forces

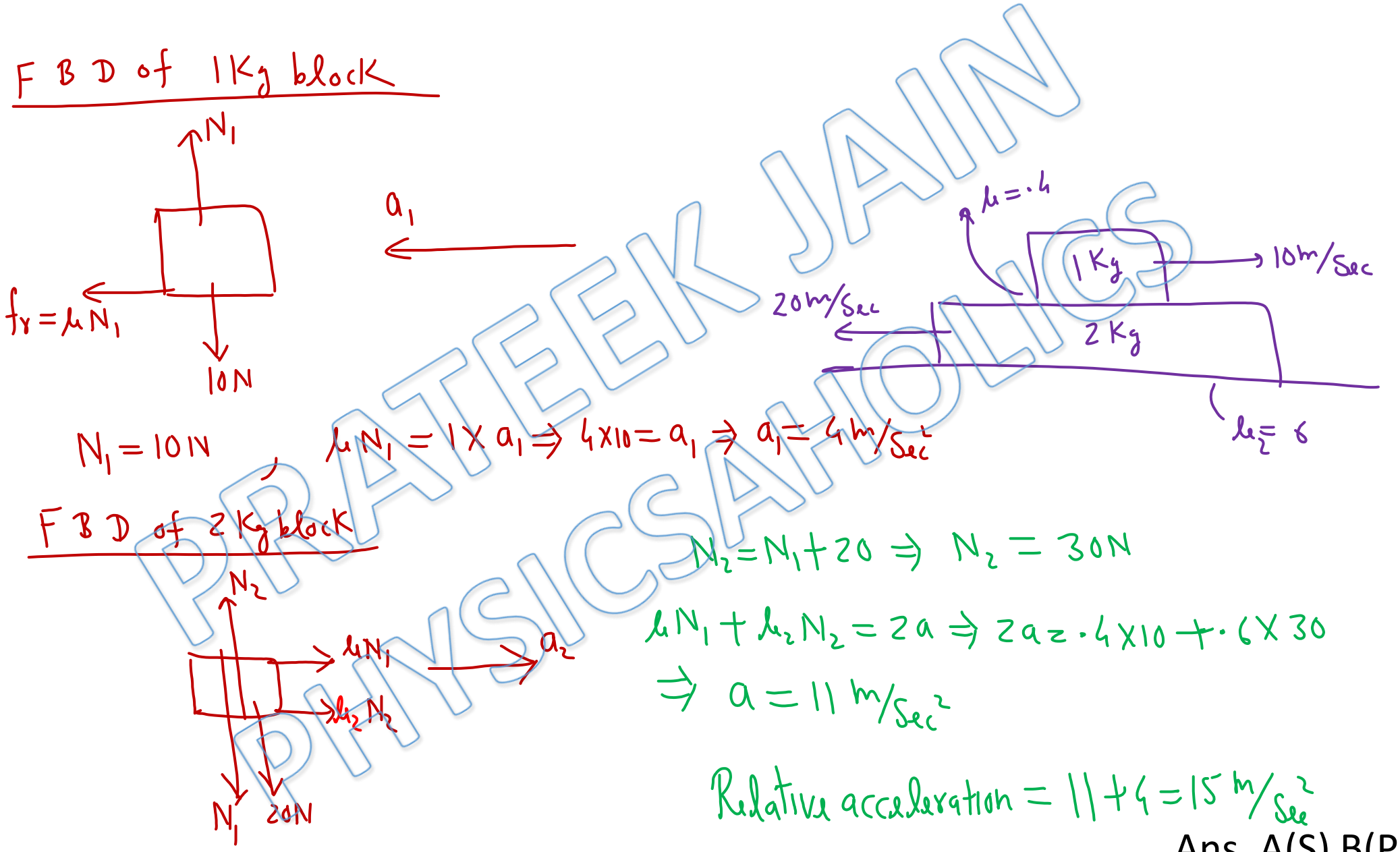
$\Rightarrow mg = .5g\cos 37 + g\sin 37$

$\Rightarrow m = .5 \times \frac{4}{5} + \frac{3}{5}$

$= 1\ Kg$

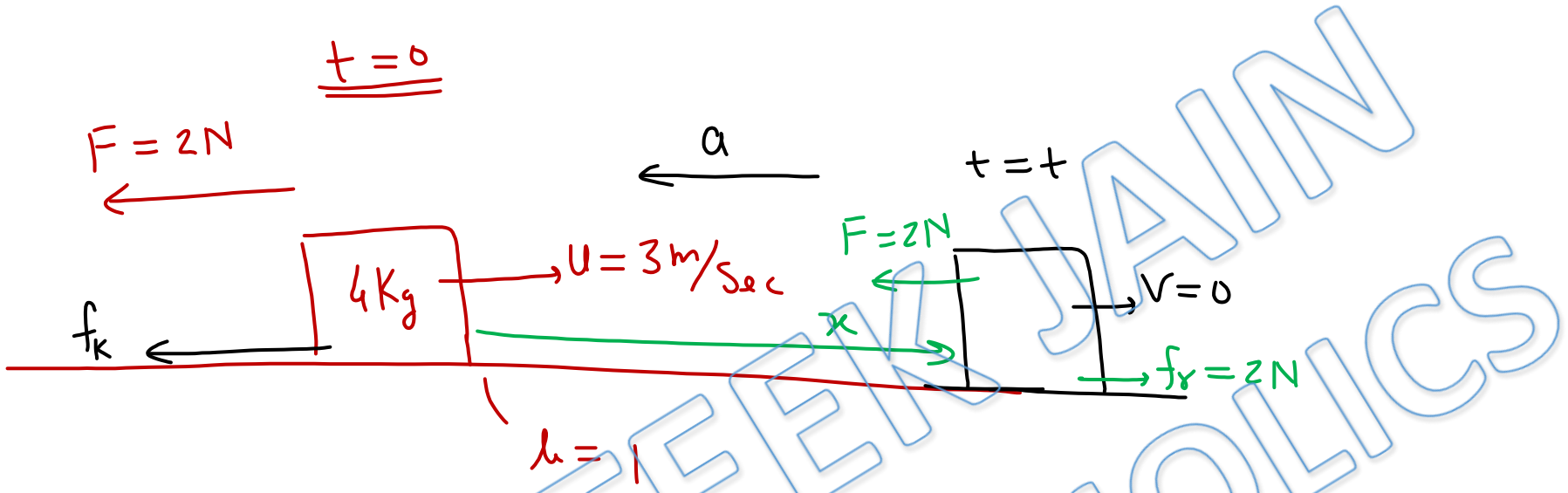
Ans (b)

Solution.5



Ans. A(S) B(P) C(S)

Solution.6



$$f_k = \mu N = .1 \times 40 = 4\,N$$

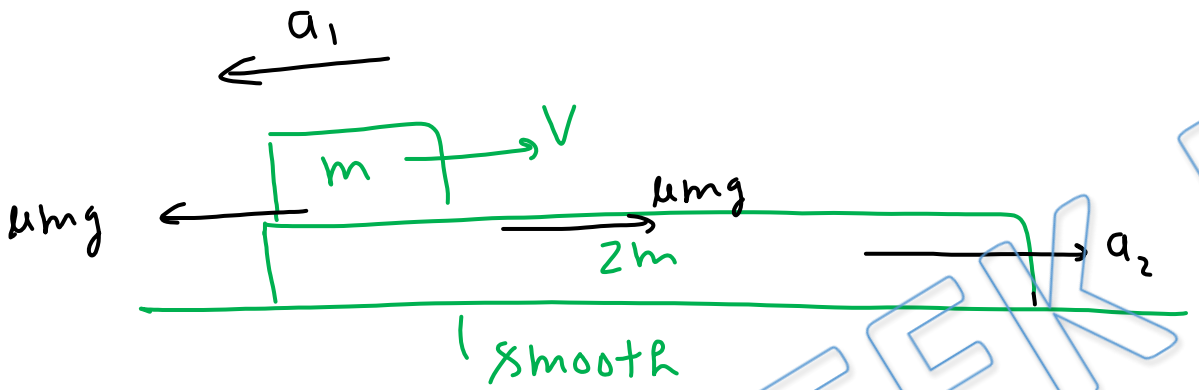
$$a = \frac{4+2}{4} = 3/2\ m/Sec^2$$

block will retard & stop after some time

$$V^2 = u^2 + 2ax \Rightarrow 0 = 9 - 2 \times 3/2\, x \Rightarrow x = 3m$$

Ans (c)

Solution.7



$$a_1 = \frac{\mu mg}{m} = \mu g$$

$$a_2 = \frac{\mu mg}{2m} = \frac{\mu g}{2}$$

relative acceleration $= \mu g + \frac{\mu g}{2} = \frac{3}{2}\mu g$

Let final Common velocity is V' & blocks achieve it at $t = t$

$$V' = V - \mu g t = \frac{\mu g}{2} t \Rightarrow \frac{3}{2}\mu g t = V \Rightarrow t = \frac{2V}{3\mu g}$$

$$\Rightarrow V' = \frac{\mu g t}{2} = \frac{\mu g}{2} \times \frac{2V}{3\mu g} = V/3$$

Ans(a,b,d)

Solution:8 taking (A+B) as a system

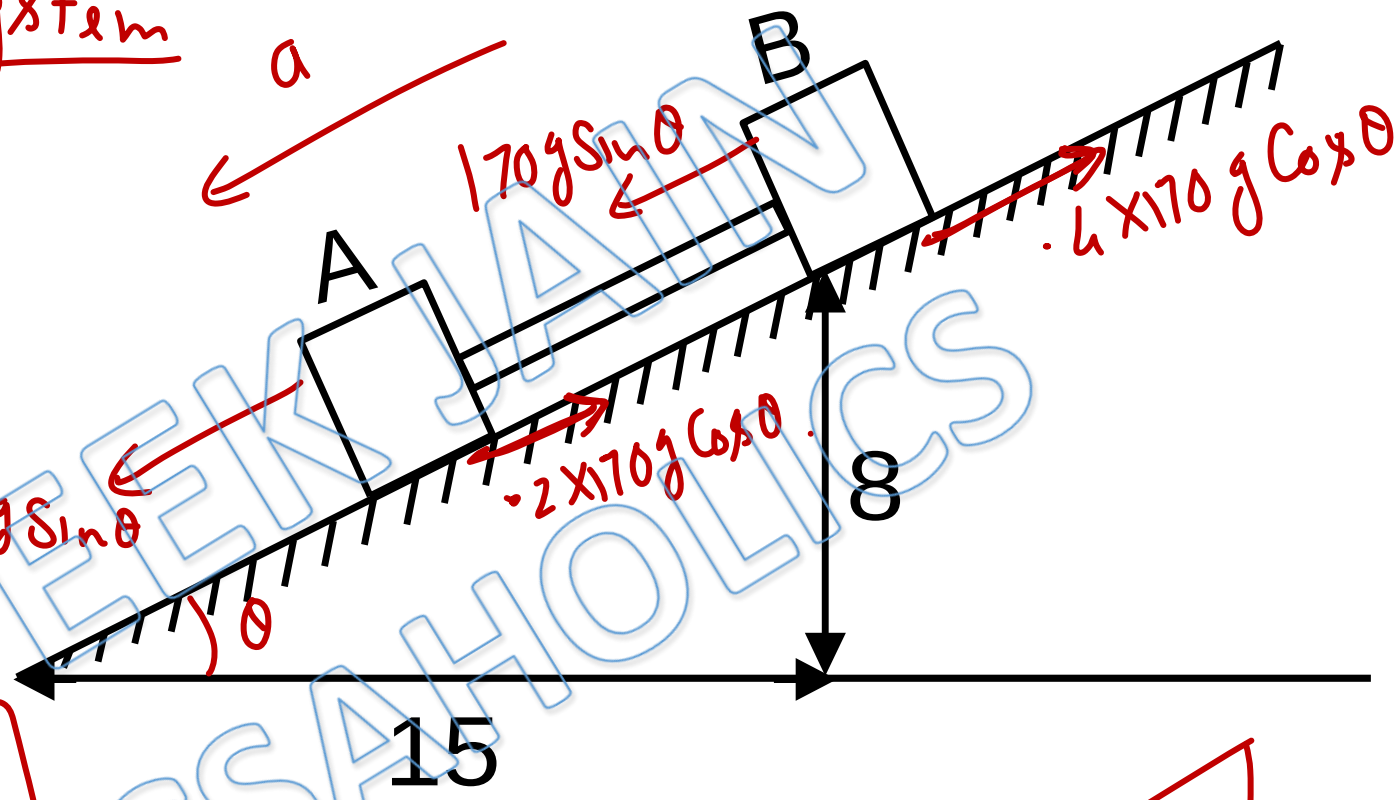
$\Rightarrow 340g\sin\theta - .6\times 170g\cos\theta$

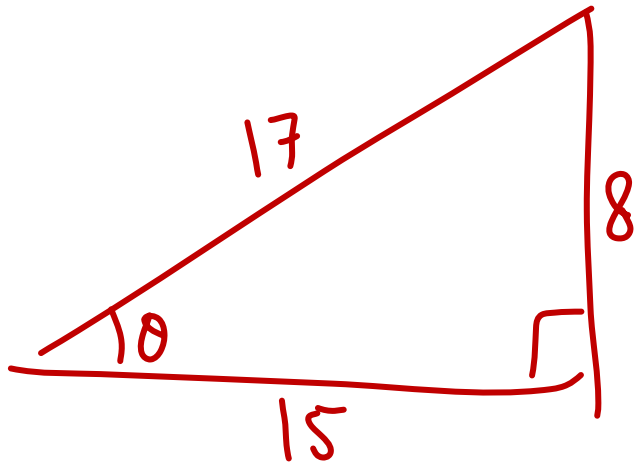
$= 340a$

$\Rightarrow a = g\sin\theta - .3g\cos\theta$

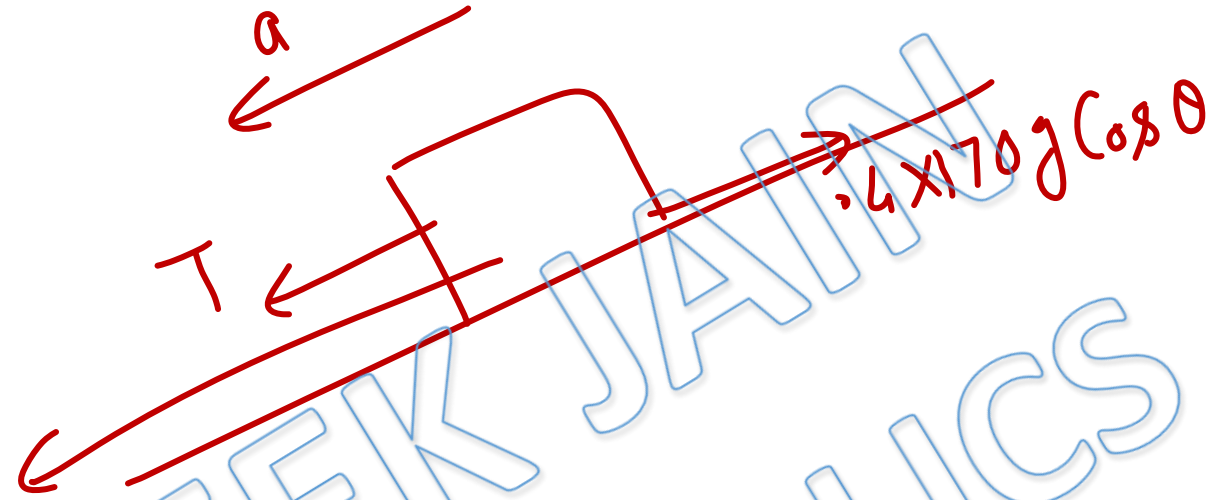
$= g\left[\frac{8}{17} - .3\times\frac{15}{17}\right]$

$= \frac{3.5g}{17} = \frac{35}{17}\ m/sec^2$





F.B.D of B →



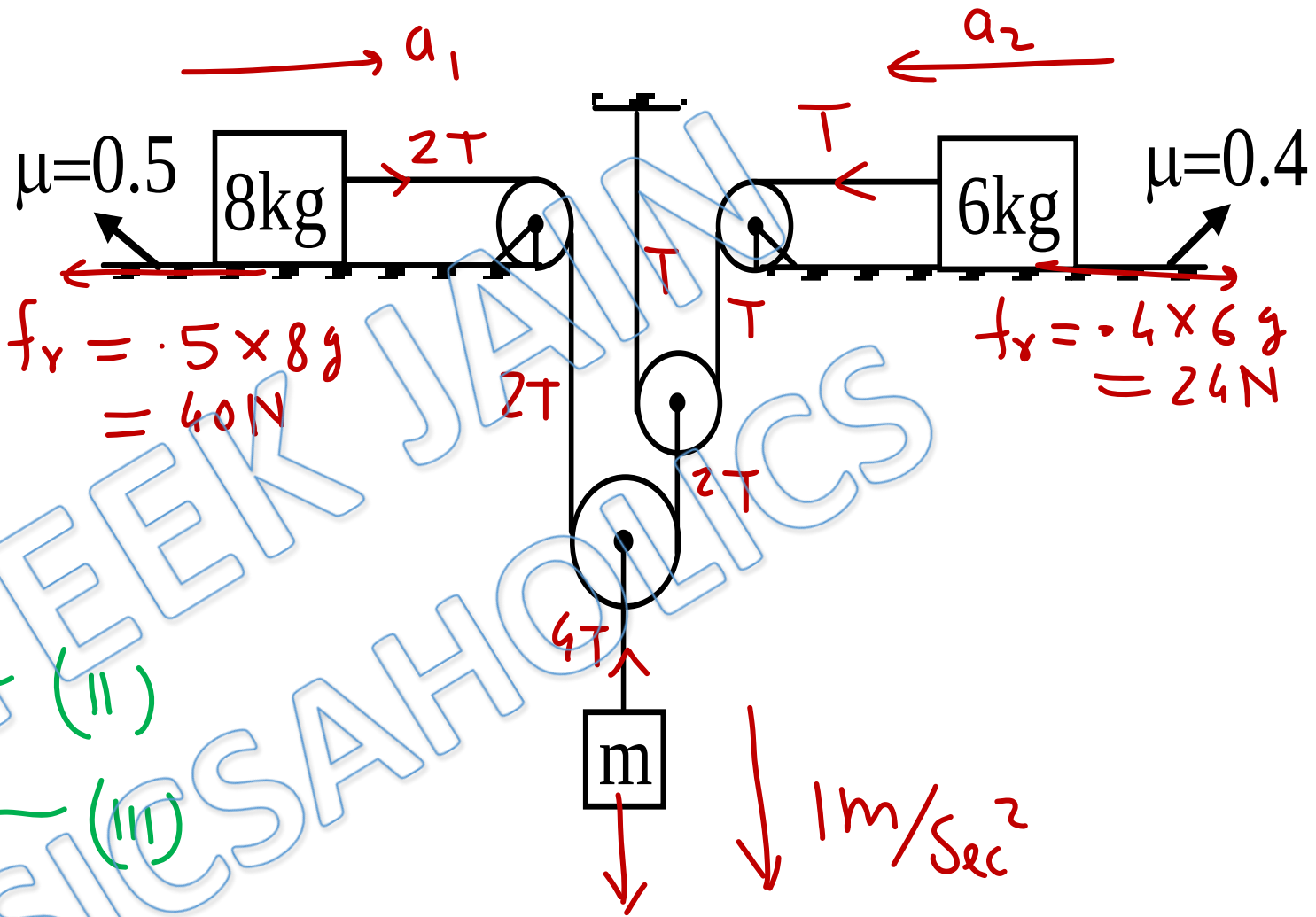
$$T + \frac{1700 \times 8}{17} - \frac{680 \times 15}{17} = 170 \times \frac{35}{17}$$

$$T = 350 + 600 - 800 = 150\,N$$

Ans (a)

Solution:9

by Using power method



$$2Ta_1 + Ta_2 - 4T \times 1 = 0$$

$$\Rightarrow \quad 2a_1 + a_2 = 4 \quad --(1)$$

$$T - 24 = 6a_2 \quad --(11)$$

$$2T - 40 = 8a_1 \quad --(11)$$

$$\Rightarrow \quad a_2 = \frac{T}{6} - 4$$

$$2a_1 = \frac{T}{2} - 10 \Rightarrow \frac{T}{6} - 4 + \frac{T}{2} - 10 = 4$$

$$T\left(\frac{1+3}{6}\right) = 18 \Rightarrow T = \frac{6\times 18}{4} = 27\ N$$

from F.B.D of m

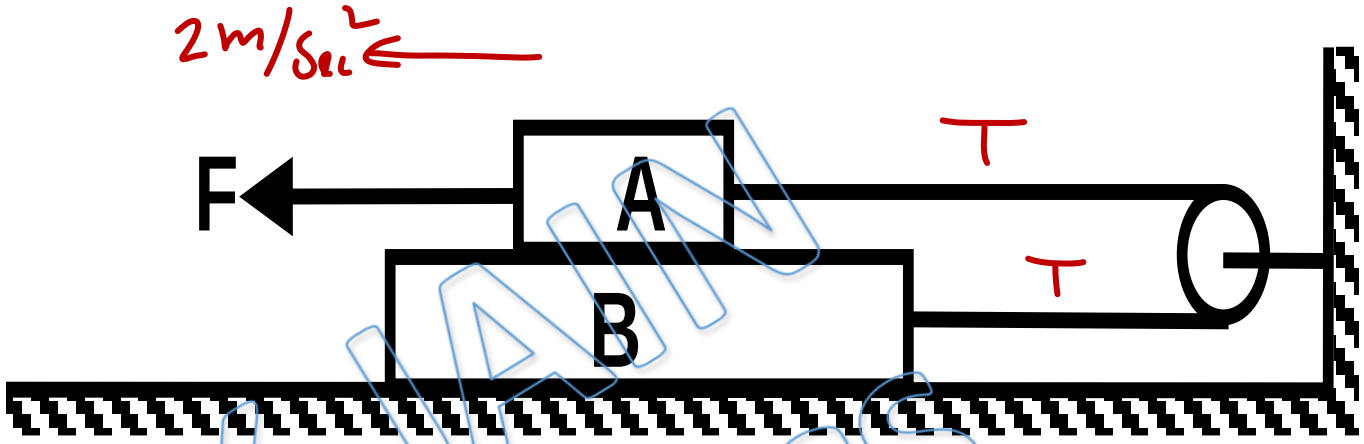
$$10m - 4T = m \times 1$$

$$\Rightarrow 9m = 4 \times 27$$

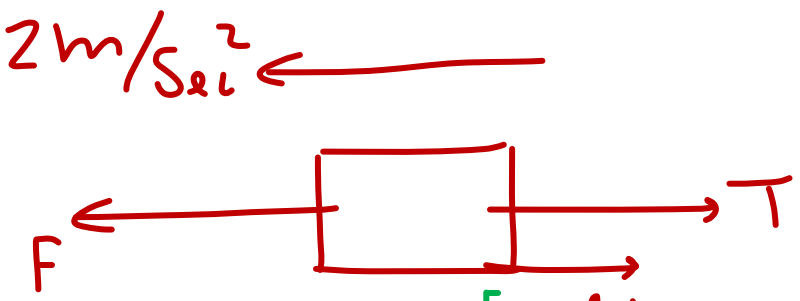
$$m = 12\ kg$$

Ans.c

Solution.10



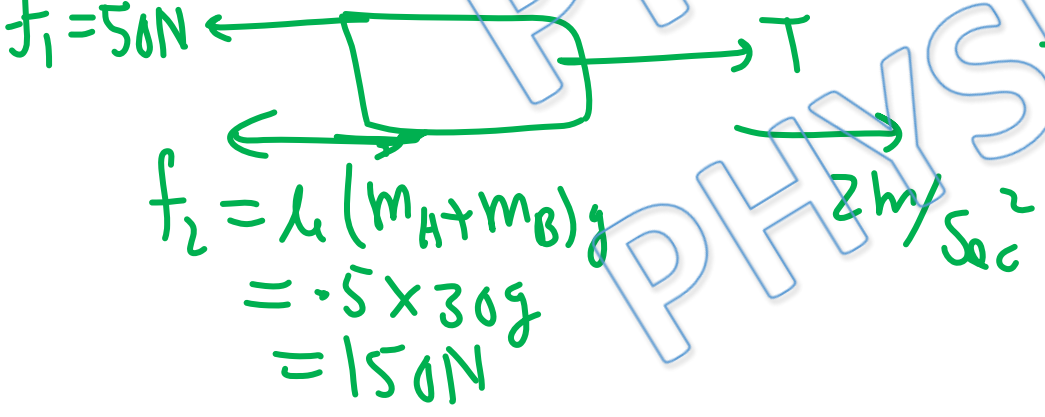
F.B.D of A



$f_1 = \mu mg = .5 \times 10g = 50N$

$F - T - 50 = 10 \times 2 \Rightarrow F - T = 70 \quad --(1)$

F.B.D. of B →



$f_2 = \mu(m_A + m_B)g$

$= .5 \times 30g$

$= 150N$

$T - 200 = 20 \times 2 = 40 \quad --(11)$

$F - 200 = 110$

$F = 310N$

Ans(d)

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