CLASS TEST

S.No.: 01DLSKCE_DEFG_150426

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ENGINEERING MECHANICS

CIVIL ENGINEERING

Date of Test : 15/04/2026

ANSWER KEY

1.	(c)	7.	(d)	13.	(b)	19.	(b)	25.	(a)
2.	(d)	8.	(b)	14.	(a)	20.	(d)	26.	(c)
3.	(b)	9.	(a)	15.	(a)	21.	(b)	27.	(b)
4.	(c)	10.	(d)	16.	(c)	22.	(a)	28.	(a)
5.	(a)	11.	(a)	17.	(d)	23.	(d)	29.	(a)
6.	(b)	12.	(c)	18.	(b)	24.	(b)	30.	(c)

DETAILED EXPLANATIONS

1. (c)

The reaction on the block (R) = 20 kg f

The horizontal force needed to move the block

$= \mu R = 0.22 \times 20$

$= 4.4$ kg f

2. (d)

$$\text{Acceleration } (a) = \frac{dv}{dt} = 3t^2 - 2t$$

at $t = 3$ sec.

$$a = 3 \times 3 \times 3 - 2 \times 3 = 21 \text{ m/s}^2$$

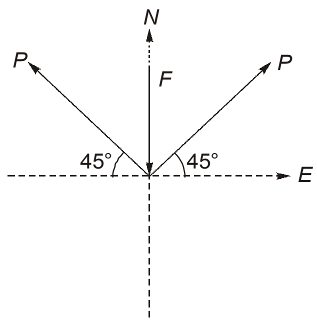
3. (b)

4. (c)

For perfectly elastic collision $e = 1.0$

5. (a)

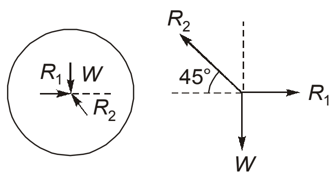
Considering equilibrium of forces in N-S direction



$$\left(\frac{P}{\sqrt{2}}\right) + \left(\frac{P}{\sqrt{2}}\right) - F = 0$$

$$F = \frac{2P}{\sqrt{2}} = \sqrt{2}P$$

6. (b)



$$R_2 \cos 45° = R_1$$

$$R_2 \sin 45° = W$$

$$\Rightarrow \quad R_2 = W\sqrt{2}$$

$$\therefore \quad R_1 = W\sqrt{2} \times \frac{1}{\sqrt{2}} = W$$

$$W = 50 \text{ N}$$

$$\therefore \quad R_1 = 50 \text{ N}$$

7. (d)

8. (b)

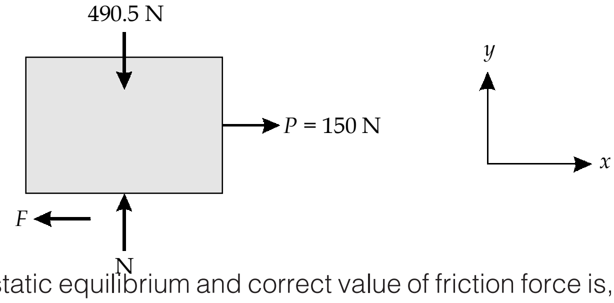
When body is at rest, for equilibrium,

$$N = 490.5 \text{ N}$$

$$\text{Applied force, } P = 150 \text{ N}$$

Maximum static friction force,

$$F_{max} = \mu s N$$
$$= 0.5\,(490.5)$$
$$= 245.25 \text{ N}$$



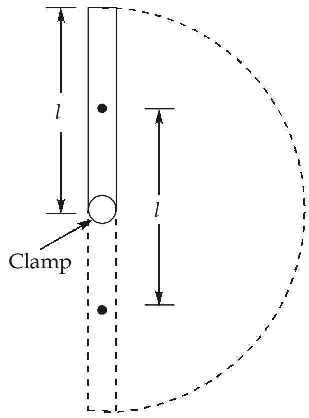
Because $P < F_{max}$, we conclude that the block is in static equilibrium and correct value of friction force is,

$$F = 150 \text{ N}$$

9. (a)

As the rod reaches it lowest position, the center of mass is lowered by a distance l. Its gravitational potential energy is decreased by mgl.

Rotation occurs about the horizontal axis through the clamped end.



$$\text{Moment of inertia, } I = \frac{ml^2}{3}$$

Now, by work energy theorem;

$$\text{Total work done} = \text{Change in kinetic energy}$$

$$(\Delta W)_{mgl} = (\text{KE})_f - (\text{KE})_i$$

$$mgl = \frac{1}{2} I\omega^2 - 0$$

$$\frac{1}{2} I\omega^2 = (mgl)$$

$$\frac{1}{2}\left(\frac{ml^2}{3}\right)\omega^2 = (mgl)$$

$$\omega^2 = \frac{6g}{l}$$

$$\omega = \sqrt{\frac{6g}{l}}$$

Linear speed of the free end at given instant, $v = l\omega$

$$V = l \times \sqrt{\frac{6g}{l}}$$

$$V = \sqrt{6gl}$$

10. (d)

$$\text{For the mass } m,\ mg - T = ma$$

$$\text{For cylinder, } T \times R = I\alpha$$

$$T \times R = mR^2 \times \frac{a}{R}$$

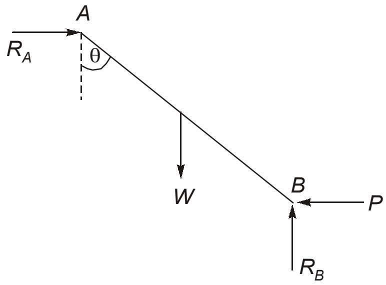
$$T = ma$$

$\Rightarrow$ $$mg = 2ma$$

$\Rightarrow$ $$a = \frac{g}{2} \text{ms}^{-2}$$

11. (a)

Free body diagram of ladder is



Using equilibrium equations.

$$R_A = P$$

and $$R_B = W$$

Taking moment about *B*.

$$R_A \cdot l\cos\theta = W \cdot \frac{l}{2}\sin\theta$$

$$RA = \frac{1}{2}W\tan\theta = P$$

12. (c)

Shape	Area	Centroid from base
Square	$A_1 = d^2$	$y_1 = d/2$
Half circle	$A_2 = \pi d^2/8$	$y_2 = 2d/3\pi$

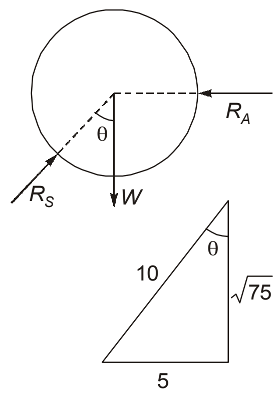
The centroid of hatched position from base.

$$\bar{y} = \frac{A_1y_1 - A_2y_2}{A_1 - A_2}$$

$$= \frac{d^2 \cdot \frac{d}{2} - \frac{\pi d^2}{8} \cdot \frac{2d}{3\pi}}{d^2 - \frac{\pi d^2}{8}} = \frac{10d}{3(8-\pi)}$$

13. (b)

FBD



$$\Sigma F_y = 0$$

$$W = R_S \cos\theta$$

$$R_S = \frac{100 \times 10}{\sqrt{75}}$$

$$\cos\theta = \frac{\sqrt{75}}{10}$$

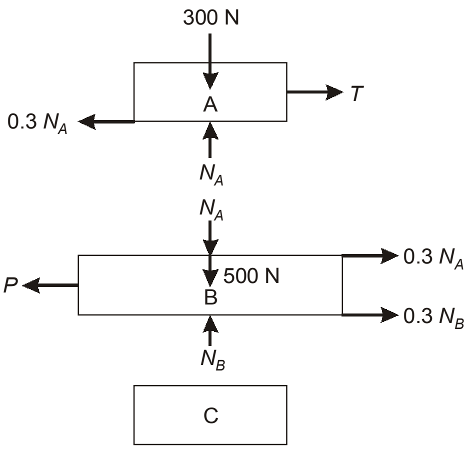
$$\sin\theta = \frac{5}{10}$$

$$\Sigma F_X = 0$$

$$R_S \sin\theta = R_A$$

$$\therefore \quad R_A = \frac{1000}{\sqrt{75}} \times \frac{5}{10} = 57.735\text{ N}$$

14. (a)



Considering first FBD of block A:

$$\Sigma F_y = 0$$

$\Rightarrow$ $N_A = 300\text{ N}$

$\Rightarrow$ $\Sigma F_x = 0$

$\Rightarrow$ $T = 0.3\ N_A = 0.3 \times 300 = 90\text{ N}$

Now consider FBD of block B:

$$\Sigma F_y = 0$$

$\Rightarrow$ $N_B = N_A + 500 = 300 + 500 = 800\text{ N}$

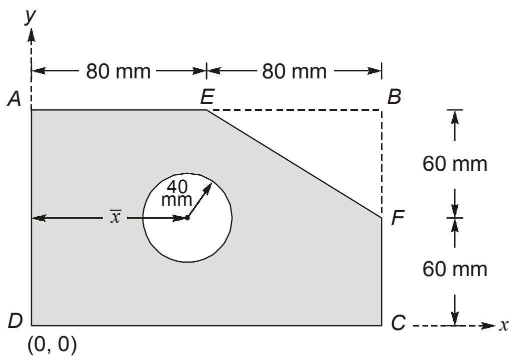
$$\Sigma F_x = 0$$

$\Rightarrow$ $P = 0.3\ N_A + 0.3\ N_B$

$\Rightarrow$ $P = 0.3\,(300 + 800)$

$= 330\text{ N}$

15. (a)



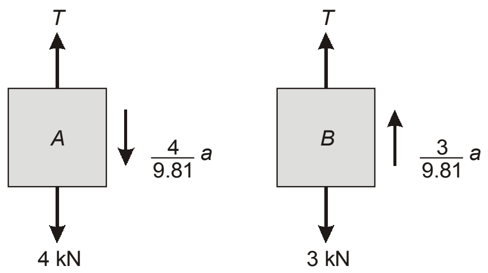
S. No.	Shape	Area (mm^2)	$\bar{x}$ (mm)	$a\bar{x}$ (mm^3)
1	*ABCD*	19200	80	1536000
2	Circle	–5026.55	$\bar{x}$	$-5026.55\bar{x}$
3	ΔEBF	–2400	133.33	–320000
		$\Sigma a = 11773.45$		$\Sigma a\bar{x} = 1216000 - 5026.55\bar{x}$

Now,
$$\bar{x} = \frac{\Sigma a\bar{x}}{\Sigma a}$$

$$\Rightarrow \quad \bar{x} = \frac{1216000 - 5026.55\bar{x}}{11773.45}$$

$$\Rightarrow \quad \bar{x} = 72.38 \text{ mm}$$

16. (c)



For block A,

$$T - \frac{4}{9.81}a = 4 \quad \text{...(i)}$$

For block B,

$$T + \frac{3}{9.81}a = 3 \quad \text{...(ii)}$$

For equation (i) and (ii), we get

$$\Rightarrow \quad \frac{7a}{9.81} = -1$$

$\therefore \quad a = -1.401 \text{ m/s}^2$ (Because of this deceleration, the system will come to rest)

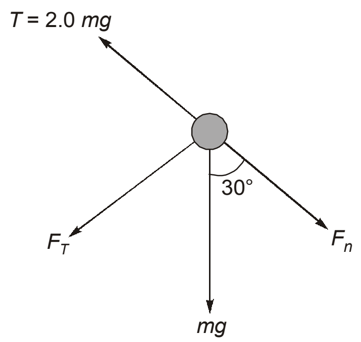
The system comes to rest when final velocity becomes zero

$$\therefore \quad v = u + at$$

$$\Rightarrow \quad 0 = 1.85 - 1.401t$$

$$\therefore \quad t = 1.32 \text{ sec}$$

17. (d)



Tangential force, $F_T = mg \sin 30° = 0.5\, mg$

Normal force, $F_n = T - mg \cos 30°$

$$\Rightarrow \quad F_n = 2\, mg - 0.866\, mg$$

$$\Rightarrow \quad F_n = 1.134\, mg$$

Normal acceleration, $a_n = \dfrac{F_n}{m}$

$$\Rightarrow \quad a_n = \frac{1.134\, mg}{m}$$

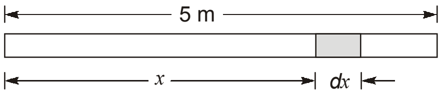
$$\Rightarrow \quad a_n = 1.134 \times 9.81 = 11.125 \text{ m/s}^2$$

$$\because \qquad a_n = \frac{V^2}{R}$$

$$\Rightarrow \qquad 11.125 = \frac{V^2}{1}$$

$$\Rightarrow \qquad V = 3.34 \text{ m/s}$$

18. (b)



Let the cross-sectional area be α. The mass of an element (dm) of length dx located at a distance x away from the left end is $(0.5 + 3x)\alpha\, dx$. The x-coordinate of the centre of mass is given by,

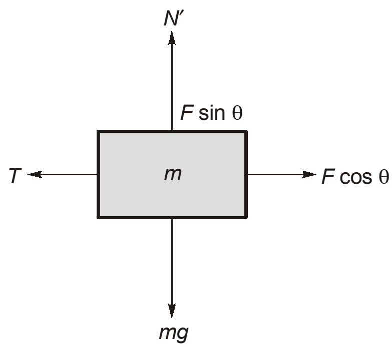
$$X_{cm} = \frac{\int x\,dm}{\int dm} = \frac{\int_0^5 x(0.5+3x)\alpha\,dx}{\int_0^5 (0.5+3x)\alpha\,dx}$$

$$= \frac{\int_0^5 (0.5x+3x^2)\alpha\,dx}{\int_0^5 (0.5x+3x)\alpha\,dx}$$

$$= \frac{0.5\left(\frac{5^2}{2}\right)+3\left(\frac{5^3}{3}\right)}{0.5\times5+3\left(\frac{5^2}{2}\right)}$$

$$= \frac{6.25+125}{2.5+37.5} \simeq 3.28 \text{ m}$$

19. (b)



Considering free body diagram

$$F\cos\theta = T + \mu N'$$

$$T\cos\theta = \mu\, mg + \mu(mg - F\sin\theta) \qquad [N' = mg - F\sin\theta]$$

$$\Rightarrow \qquad F = \frac{2\mu mg}{\cos\theta + \mu\sin\theta}$$

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

$\because$ [Max value of $a\cos\theta + b\sin\theta$ is $\sqrt{a^2+b^2}$]

20. (d)

Let the velocity of box as it reaches point D is v.
Energy conservation between A and D

$$mg \times 100 = mg \times 60 + \frac{1}{2}mv^2$$

$$v = 28.01 \text{ m/s}$$

As the box reaches the highest point after take off, it will have velocity,

$$v_h = v\cos\theta = 28.01 \times \cos(30)$$

$$v_h = 24.26 \text{ m/s}$$

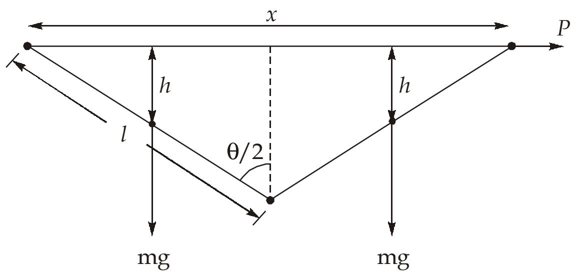
Energy conservation between A and the highest point

$$mg \times 100 = mg \times h_{max} + \frac{1}{2}m \times (24.26)^2$$

$$h_{max} = 70 \text{ m}$$

21. (b)

Apply virtual work method,



$$x = 2l\sin\left(\frac{\theta}{2}\right)$$

$$h = \frac{l}{2}\cos\left(\frac{\theta}{2}\right)$$

$$\Rightarrow \quad dx = 2l\cos\left(\frac{\theta}{2}\right)\frac{d\theta}{2}$$

$$dh = -\frac{l}{2}\sin\left(\frac{\theta}{2}\right)\frac{d\theta}{2}$$

$$\Rightarrow \quad \frac{dx}{\cos\left(\frac{\theta}{2}\right)} = -\frac{dh}{\sin\left(\frac{\theta}{2}\right)} \times 4$$

By principle of virtual work,

$$\Rightarrow \quad Pdx + 2mgdh = 0 = WD$$

$$\Rightarrow \quad P \times dx = 2mg \times \tan\left(\frac{\theta}{2}\right) \times \frac{dx}{4}$$

$$\Rightarrow \quad \frac{2P}{mg} = \tan\left(\frac{\theta}{2}\right)$$

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

$$\theta = 90^\circ$$

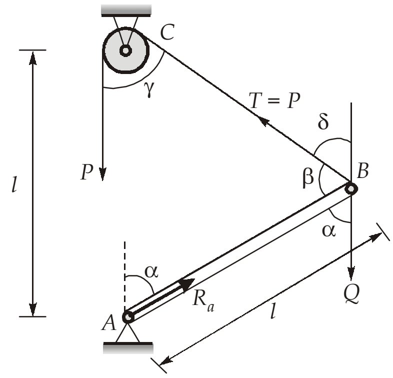
22. (a)

There are three forces acting on the bar AB; pull Q at B, tension in string T and reaction at point A i.e. R_a.
For isosceles triangle ABC,

$$\beta = \gamma = \left(\frac{\pi-\alpha}{2}\right) = 90° - \left(\frac{\alpha}{2}\right)$$

If there is no friction on pulley, tension in string BC will be P.

Taking moment about point A,



$$(P\cos\delta) \times (l\sin\alpha) + (P\sin\delta)(l\cos\alpha) = Ql\sin\alpha$$

$$Pl\sin(\alpha+\delta) = Ql\sin\alpha$$

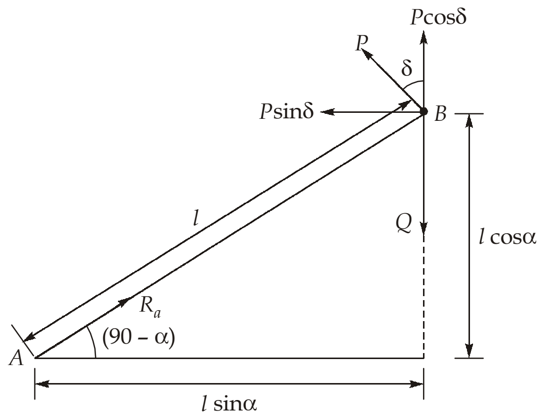
$$P\sin(180° - \beta) = Q\sin\alpha$$

$$P\sin\left[180 - 90 + \frac{\alpha}{2}\right] = Q\sin\alpha$$

$$P\cos\frac{\alpha}{2} = 2Q\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}$$

$$\left(\cos\frac{\alpha}{2}\right)\left[P - 2Q\sin\frac{\alpha}{2}\right] = 0$$

or $$\sin\frac{\alpha}{2} = \frac{P}{2Q}$$



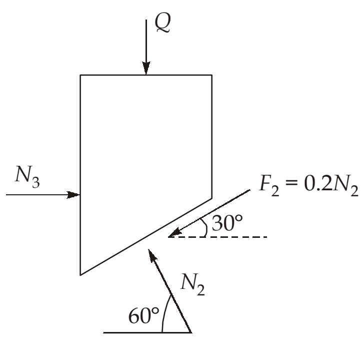
$$\alpha = 2\sin^{-1}\left(\frac{P}{2Q}\right) = 2\sin^{-1}\left(\frac{900}{2\times 2200}\right) = 23.6057°$$

$$\alpha = 23.6057 \times \left(\frac{\pi}{180}\right) = 0.412 \text{ radian}$$

23. (d)

From Newton's first law,

$\Sigma F_y = 0$



$$N_2\sin 60° - 0.2N_2\sin 30° - Q = 0$$

$$Q = 0.766\,N_2$$

$\Sigma F_X = 0$

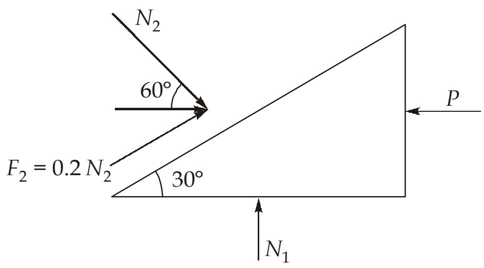
$N_2 \cos 60° + 0.2 N_2 \cos 30° - P = 0$

$$P = 0.673 N_2$$

$$\frac{P}{Q} = \frac{0.673}{0.766}$$

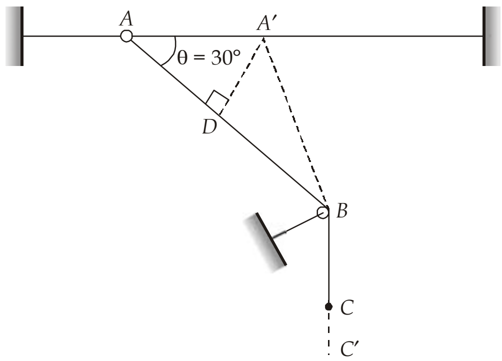
$$P = 0.878Q \simeq 0.9Q$$

$$\alpha = 0.9$$



24. (b)

Suppose in small time interval Δt, the ring is displaced from A to A′ and the block from C to C′.



Now $AB + BC = A'B + BC'$

$\Rightarrow \quad AD + DB + BC = A'B + BC'$

$\Rightarrow \quad AD = BC' - BC \qquad [\because A'B \simeq DB]$

$\Rightarrow \quad AD = CC' \qquad \left[\cos\theta = \frac{AD}{AA'}\right]$

$\Rightarrow \quad \frac{AA'\cos\theta}{\Delta t} = \frac{CC'}{\Delta t}$

$\Rightarrow \quad V\cos\theta = V'$

$\Rightarrow \quad V' = 10 \times \cos 30° = 8.66 \text{ km/hr}$

25. (a)

Let speed of car moving in opposite direction is V km/hr.

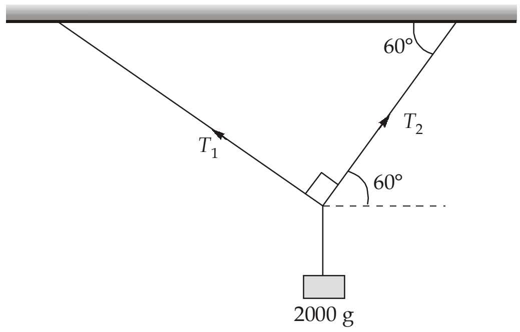
From relative velocity approach, velocity of opposite direction car = V + 80

$\therefore \quad \frac{\text{Distance}}{\text{Velocity}} = \text{Time}$

$\Rightarrow \quad \frac{20}{V+80} = \frac{8}{60}$

$\Rightarrow \quad V = 70 \text{ kmph} = 19.44 \text{ m/s}$

26. (c)



Using Lami's theorem, $\frac{T_1}{\sin(90° + 60°)} = \frac{T_2}{\sin(360° - (90° + 60° + 90°))}$

$$\Rightarrow \quad \frac{T_1}{\sin 150°} = \frac{T_2}{\sin 120°}$$

$$\Rightarrow \quad \frac{T_1}{T_2} = 0.577$$

27. (b)

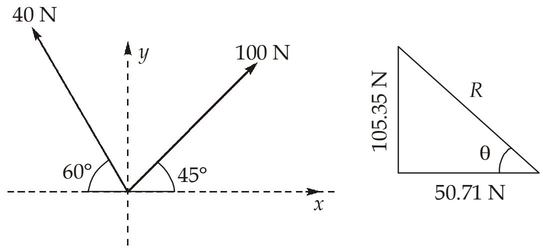
Resolving the forces in horizontal and vertical components.

In x-direction,

$$\Rightarrow \quad \Sigma F_x = 100\cos 45° - 40\cos 60°$$

$$\Rightarrow \quad \Sigma F_x = 70.71 - 20$$

$$\Rightarrow \quad \Sigma F_x = 50.71 \text{ N}$$



In y-direction,

$$\Sigma F_y = 40\sin 60° + 100 \sin 45°$$

$$\Rightarrow \quad \Sigma F_y = 105.35 \text{ N}$$

∴ Resultant of given forces, $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$$\Rightarrow \quad R = \sqrt{(50.71)^2 + (105.35)^2}$$

$$\Rightarrow \quad R = 116.92 \text{ N}$$

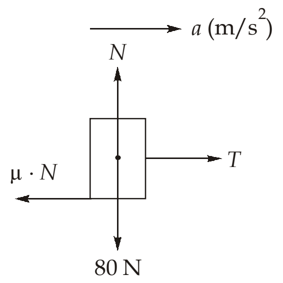
$$\Rightarrow \quad \theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$

$$\Rightarrow \quad \theta = \tan^{-1}\left(\frac{105.35}{50.71}\right)$$

$$\Rightarrow \quad \theta = 64.3° \text{ from } x\text{-axis}$$

28. (a)

FBD of 80 N block,



$$\Sigma F_y = 0,$$

$$\Rightarrow \quad N = 80 \text{ N}$$

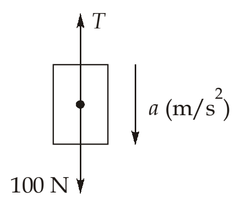
$$\Sigma F_x = ma,$$

$$\Rightarrow \quad T - \mu N = ma$$

$$\Rightarrow \quad T - 0.2(80) = \frac{80 \cdot a}{g} \qquad [\because \ W = mg]$$

$$\Rightarrow \quad T - 16 = \frac{80a}{g} \qquad \text{...(i)}$$

FBD of 100 N block,



$$\Sigma F_y = ma$$

$$\Rightarrow \quad 100 - T = ma$$

$$\Rightarrow \quad 100 - T = \frac{100 \cdot a}{g} \qquad \text{...(ii)}$$

From equation (i) and (ii),

$$100 - \left(16 + \frac{80a}{g}\right) = \frac{100a}{g}$$

$$\Rightarrow \quad 84 = \frac{180a}{g}$$

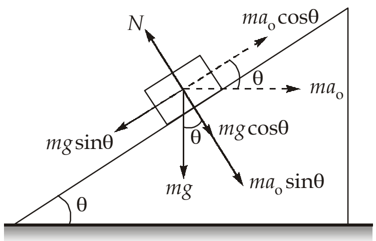
$$\Rightarrow \quad a = \frac{7g}{15} \text{m/s}^2$$

$$\therefore \quad T = 16 + \frac{80}{g}\left(\frac{7g}{15}\right) = 53.33 \text{ N}$$

29. (a)

Let the acceleration of system be a_0 in the left direction due to applied force P.

Consider the motion of rectangular block from the frame of prism which is non-inertial. A pseudo force equal to ma_0 has to be applied on rectangular block in the right direction.



To prevent sliding of rectangular block.

$$mg\sin\theta = ma_0\cos\theta$$

$$\Rightarrow \quad a_0 = g \quad \text{...(i)}$$

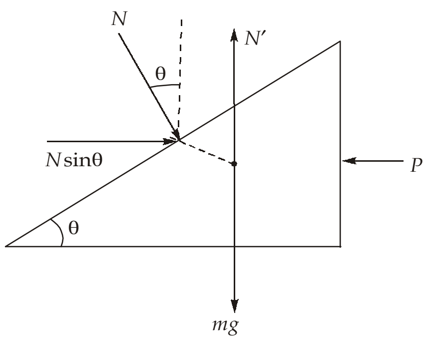
Now,

$$N = mg\cos\theta + ma_0\sin\theta$$

$$\Rightarrow \quad N = mg\cos 45° + ma_0\sin 45°$$

$$\Rightarrow \quad N = \sqrt{2}\,mg \quad \text{...(ii)}$$

Considering motion of prism,



$$\therefore \quad P - N\sin\theta = ma_0$$

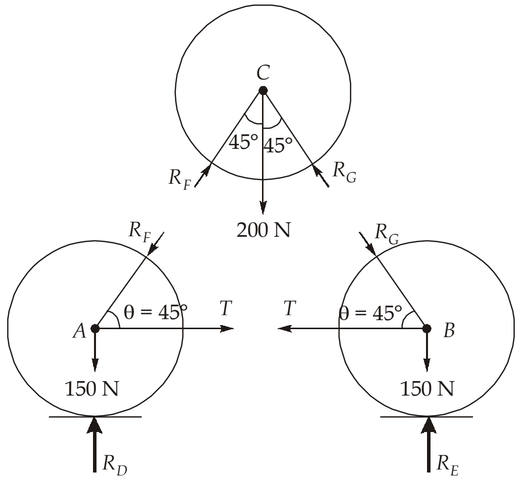
$$\Rightarrow \quad P = ma_0 + N\sin 45°$$

$$\Rightarrow \quad P = mg + \sqrt{2}mg \times \frac{1}{\sqrt{2}} \quad \text{\{from (i) and (ii)\}}$$

$$\therefore \quad P = 2\,mg$$

30. (c)

The free body diagram of all the three cylinder are as shown below:



Consider the free body diagram of cylinder *C*.
Each cylinder in in equilibrium.

$$\therefore \qquad \theta = \cos^{-1}\left(\frac{170}{240}\right) = 44.9° \simeq 45°$$

Let, R_G and R_F are the reactive forces.
Applying equilibrium conditions:

$$\Sigma F_x = 0$$

$$\Rightarrow \quad R_F \sin 45° - R_G \sin 45° = 0$$

$$R_F = R_G$$

$$\Sigma F_y = 0$$

$$\Rightarrow \quad R_F \cos 45° + R_G \cos 45° = 200$$

$$\Rightarrow \quad R_F = R_G = \frac{200}{2\cos 45°} = 141.42 \text{ N}$$

Similarly, considering freebody diagram of cylinder A and applying equilibrium conditions,

$$\Sigma F_x = -R_F \cos 45° + T = 0$$

$$\Rightarrow \quad T = R_F \cos 45° = 141.42 \times \cos 45°$$

$$= 99.999 \text{ N}$$

$$\simeq 100 \text{ N}$$

$$\Sigma F_y = -R_F \sin 45° - 150 + R_D = 0$$

$$\Rightarrow \quad R_D = R_F \sin 45° + 150$$

$$= 141.42 \times \sin 45° + 150 = 250 \text{ N}$$

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