CLASS TEST

S.No.: 01DLSKCE_ABC_18032026

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ENGINEERING MECHANICS

CIVIL ENGINEERING

Date of Test : 18/03/2026

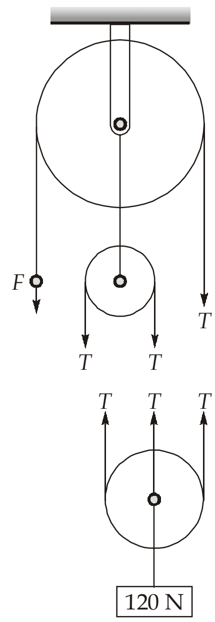
ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

The rope is same all over the pulley tension (T) everywhere in the rope will be same.



Hence, $F = T$

and $3T = 120$

$\Rightarrow$ $F = T = \dfrac{120}{3} = 40$ N

2. (b)

The area under the force displacement curve will give the net work done by the force on the particle.

$$W_{net} = 10\times2-\frac{1}{2}\times10\times2 = 20-10 = 10 \text{ J}$$

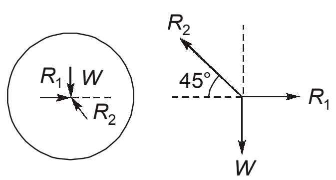
Using work energy theorem,

$$W_{net} = \text{Change in kinetic energy}$$
$$10 = (KE)_f - KE_i$$
$$10 = \frac{1}{2}Mv^2 - 0$$
$$v = \sqrt{\frac{20}{M}} = \sqrt{\frac{20}{5}} = \sqrt{4} = 2 \text{ m/ s}$$

3. (b)

$$R_2 \cos 45° = R_1$$
$$R_2 \sin 45° = W$$
$\Rightarrow$ $R_2 = W\sqrt{2}$

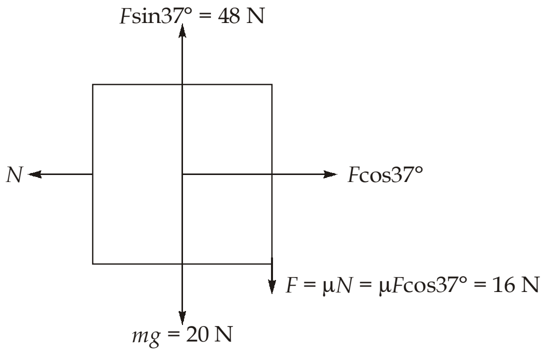
$\therefore$ $R_1 = W\sqrt{2}\times\dfrac{1}{\sqrt{2}} = W$



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

4. (c)

Free-body diagram of the block is given as:



As the upward force [$F\sin37° = 48$ N] is greater than the total downward force (20 + 16 = 36 N) hence, it has an upward acceleration,

$$F_{net,\,y} = ma$$
$$[48 - (20 + 16)] = 2a$$
$$48 - 36 = 2a$$
$$a = \frac{12}{2} = 6\text{ m/ s}^2$$

5. (d)

For no tipping or prevent overturning

$$Ph < \frac{Wb}{2}$$

where $W \rightarrow$ weight of block

and $b \rightarrow$ width of block

$$h < \frac{Wb}{2P} \quad \text{...(1)}$$

and for slipping without tipping

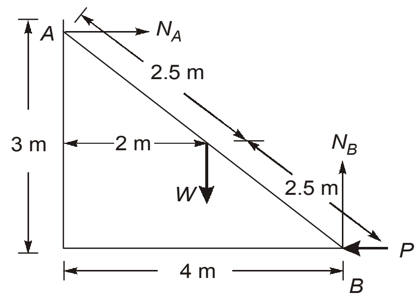
$$P > f\text{(force of friction)}$$
$$P > \mu W \quad \text{...(2)}$$

From (1) and (2)

$$h < \frac{b}{2\mu}$$
$$\therefore \quad h < \frac{60}{0.6}$$
$$\therefore \quad h < 100\text{ mm}$$

Option (d) is correct.

6. (d)



Considering equilibrium of ladder

$$N_A = P \quad [\because \vec{F}_H = 0]$$

$$W = N_B \quad [\because \vec{F}_V = 0]$$

$$\Sigma M_B = 0$$

$$N_A \times 3 - W \times 2 = 0$$

$$W = \frac{N_A \times 3}{2} = \frac{P \times 3}{2} = \frac{400 \times 3}{2} = 600 \text{ N}$$

8. (d)

For the mass m, $mg - T = ma$

For cylinder, $T \times R = I\alpha$

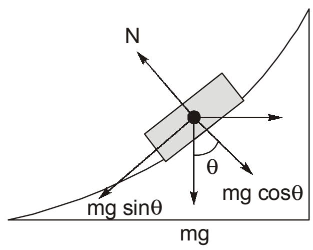
$$T \times R = mR^2 \times \frac{a}{R}$$

$$T = ma$$

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

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

9. (b)



$$\tan\theta = \frac{dy}{dx} = \frac{x^2}{2}$$

Now, $$mg\sin\theta = \mu mg\cos\theta$$

$$\Rightarrow \quad \tan\theta = \mu$$

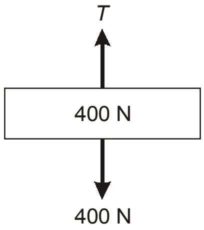
$$\Rightarrow \quad \frac{x^2}{2} = 0.5$$

$$\Rightarrow \quad x = 1$$

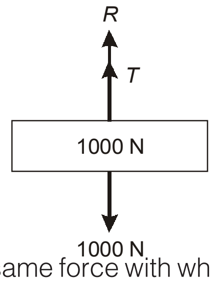
$$y = \frac{1}{6} \text{m}$$

10. (b)

Drawing free diagram of blocks, we have,



$$T = 400 \text{ N}$$



$$T + R = 1000$$

$\therefore$ $$400 + R = 1000$$

$$R = 600 \text{ N}$$

This is the reaction from the ground and it is the same force with which the 1000 N block press against the floor.

11. (c)

$$a = \frac{dv}{dt}$$

Let resisting force,

$\Rightarrow$ $$F = Kv^2$$

Let m is mass of bullet

$\therefore$ $$a = \frac{F}{m} = \frac{Kv^2}{m}$$

$$\frac{dv}{dt} = \frac{Kv^2}{m}$$

$$\frac{1}{v^{-2}}dv = \frac{K}{m}\cdot dt$$

$$\left[\frac{v^{-1}}{-1}\right]_u^v = \frac{K}{m}\int_0^t dt$$

$\Rightarrow$ $$\left[\frac{v-u}{uv}\right] = \frac{K}{m}t$$

$\Rightarrow$ $$t = \frac{(u-v)}{uv} \times \frac{-m}{K}$$

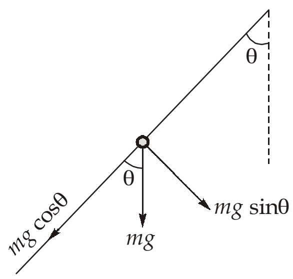
$\therefore$ $$t \propto (u-v)\,(uv)^{-1}$$

12. (a)

Value of AB is given as,

$$AB = 2\,R\cos\theta$$

Free-body diagram of the bead is given by



Acceleration of bead along AB is given as

$$a = \frac{F_{net}}{m} = \frac{mg\cos\theta}{m} = g\cos\theta$$

Using 2nd equation of kinematics along AB,

$$S = ut + \frac{1}{2}at^2$$

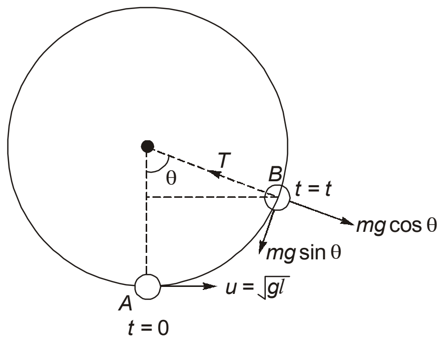
$$AB = \frac{1}{2}at^2$$

$$\therefore \quad 2R\cos\theta = \frac{1}{2}\times g\cos\theta\times t^2$$

$$\therefore \quad 2R = \frac{g}{2}t^2$$

$$t = 2\sqrt{\frac{R}{g}}$$

13. (c)



Let $T = mg$ at angle θ shown in figure

$$h = l(1-\cos\theta) \quad ...(1)$$

Apply conservation of mechanical energy between points A and B,

$$\frac{1}{2}m\left(u^2 - v^2\right) = mgh$$

$$u^2 = gl \quad ...(2)$$

v = Speed of particle in position on B

$$v^2 = u^2 - 2gh \quad ...(3)$$

$$T - mg\cos\theta = \frac{mv^2}{l}$$

$$mg - mg\cos\theta = \frac{mv^2}{l}$$

$$\Rightarrow \quad v^2 = gl(1-\cos\theta) \quad ...(4)$$

Substituting the values of v^2, u^2 and h from equations (4), (2) and (1) in equation (3).

$$gl(1-\cos\theta) = gl - 2gl(1-\cos\theta)$$

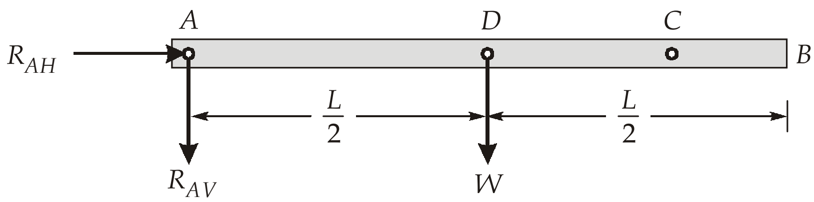
$$\cos\theta = \frac{2}{3}$$

$$\theta = \cos^{-1}\left(\frac{2}{3}\right)$$

Substituting $\cos\theta = \frac{2}{3}$ in equation (4),

$$v = \sqrt{\frac{gl}{3}}$$

14. (c)



Moment of inertia of the rod about point A,

$$I_A = \frac{\frac{W}{g}(L)^2}{12} + \frac{W}{g}\left(\frac{L}{2}\right)^2 = \frac{1}{3}\times\frac{W}{g}\times L^2$$

The net torque about point A,

$$\Sigma T_A = I_A\alpha_A$$

$$W\times\frac{L}{2} = \frac{1}{3}\times\frac{W}{g}\times L^2\alpha_A$$

$$\Rightarrow \quad \alpha_A = \frac{3g}{2L}$$

Hence, the angular acceleration of the rod at the instant is $\frac{3g}{2L}$

Now, using Newton's second law of motion.

$$\Sigma F_{\text{external, vertical}} = ma_{\text{cm, vertical}}$$

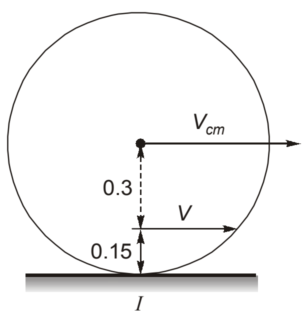
$$W - R_{AV} = \left(\frac{W}{g}\right)\times r_{cm}\times\alpha$$

$$\Rightarrow \quad W - R_{AV} = \left(\frac{W}{g}\right)\times\frac{L}{2}\times\frac{3g}{2L}$$

$$\Rightarrow \quad R_{AV} = W - \frac{3W}{4} = \frac{W}{4}$$

Hence, the vertical reaction at hinge point A at the instant is $\frac{W}{4}$.

15. (a)



$$V_{cm} = 0.45\,\omega$$

$$\omega = \frac{3}{0.45}\text{ rad/s}$$

$$V = 0.15\ \omega = \frac{0.15 \times 3}{0.45}$$

$$V = 1 \text{ m/s}$$

16. (d)

$$\omega_0 = 8000 \text{ rpm} = 837.33 \text{ rad/s}$$

$$t = 5 \text{ min} = 300 \text{ s}$$

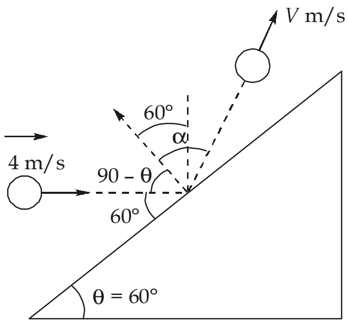
$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\alpha = \frac{\omega - \omega_0}{t} = -\frac{837.33}{300} = -2.791 \text{ rad/s}^2$$

$$\theta = 837.33 \times 300 - 0.5 \times 2.791 \times (300)^2 = 125604 \text{ rad}$$

$$\therefore \quad \text{Number of revolutions} = \frac{\theta}{2\pi} = 19990 \simeq 20000$$

17. (b)



Since the impact is occuring normal to the incline, there will be no change in velocity along the incline so,

$$4\cos(60°) = V\sin\alpha$$

$$V\sin\alpha = 2 \quad \text{...(i)}$$

Now,

$$\text{Coefficient of restitution} = \frac{\text{Velocity of separation along the line of impact}}{\text{Velocity of approach along the line of impact}}$$

$$e = \frac{V\cos\alpha}{4\sin(60°)}$$

$$0.5 = \frac{V\cos\alpha}{4\sin(60°)}$$

$$V\cos\alpha = 1.732 \quad \text{...(ii)}$$

Dividing (i) by (ii)

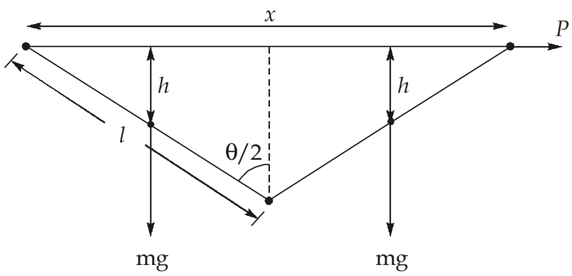
$$\tan\alpha = \frac{2}{1.732}$$

$$\alpha = 49.1074°$$

$$\text{Angle made with vertical} = 60 - 49.1074 = 10.8926°$$

18. (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,

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

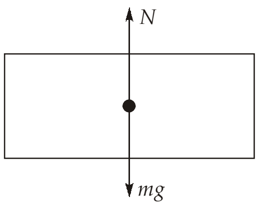
$$\Rightarrow \quad P\times dx = 2mg\times\tan\left(\frac{\theta}{2}\right)\times\frac{dx}{4}$$

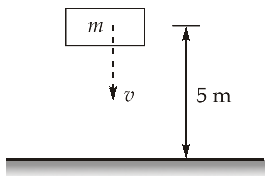
$$\Rightarrow \quad \frac{2P}{mg} = \tan\left(\frac{\theta}{2}\right)$$

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

$$\theta = 90°$$

19. (d)





Initial condition

Velocity when block reaches the ground = $\sqrt{2gh}$

$$= \sqrt{2\times 10\times 5} = 10 \text{ m/s}$$

By momentum conservation:

$(F)\times dt$ = Momentum just after striking the ground – momentum just before striking the ground

$$(N - mg)\times dt = m\times 0 - (-m\times 10)$$

$$(N - mg) = \frac{m\times 10}{dt}$$

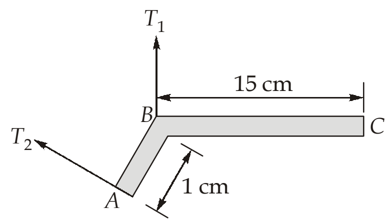
$$N = \frac{10\times 10}{(1/10)} + 10\times 10$$

Force of interaction, $N = 1100$ N

20. (b)

Given: Coefficient of friction, $\mu_k = 0.20$, Contact angle, $\theta = \frac{240}{180}\pi = 4.189$ rad, Torque, $\tau = 200$ N-m

Since, the drum is rotating in the clockwise direction. The frictional resistance acting on the drum will be in the clockwise direction. Therefore, tension T_2 will act on the left end of the band and tension T_1 at the right end.



$$\text{Torque, } \tau = (T_2 - T_1)r$$
$$200 = (T_2 - T_1) \times 0.25$$
$$T_2 - T_1 = 800 \text{ N} \quad \text{... (i)}$$

Also,
$$\frac{T_2}{T_1} = e^{\mu_k \theta} = e^{0.2 \times 4.189}$$
$$T_1 = 0.433 T_2 \quad \text{... (ii)}$$

Solving equation (i) and (ii),

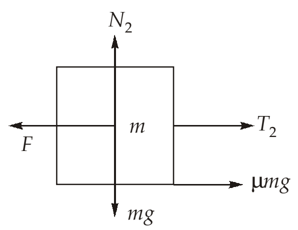
$$T_2 = \frac{800}{(1-0.433)} = 1410.93 \text{ N}$$

Taking moment about the point B,

$\Sigma M_B = 0$,
$$-T_2 \times 1 + P \times 15 = 0$$
$$P = \frac{T_2 \times 1}{15} = \frac{1410.93 \times 1}{15} = 94.06 \text{ N}$$

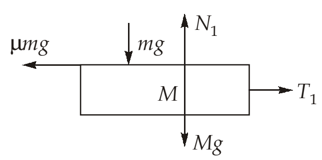
21. (d)

FBD for M:



$$\Sigma F_x = 0$$
$$\Rightarrow \quad T_1 = \mu mg$$
$$\Sigma F_x = 0$$
$$N_1 = (M + m)g$$

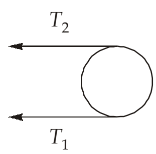
FBD for m:



$$\Sigma F_x = 0$$
$$\Rightarrow \quad F = T_2 + \mu mg$$

Pulley:

Since T_2 is tension at tight side,



$$T_2 = T_1 e^{\mu\pi}$$
$$\Rightarrow \quad F = e^{\mu\pi} \times \mu mg + \mu mg$$
$$\Rightarrow \quad F = \mu mg\,(1 + e^{\mu\pi})$$

22. (a)

Initially

Maximum kinetic energy will be recovered if collision is perfectly elastic ($e = 1$)

Momentum conservation: $mu = mv_1 + mv_2$

$$v_1 + v_2 = u \qquad \text{...(i)}$$

$$e = 1$$

$$\Rightarrow \quad e = \frac{v_2 - v_1}{u}$$

$$v_2 - v_1 = u \qquad \text{...(ii)}$$

From (i) and (ii)

$$v_2 = u,\ v_1 = 0$$

$$kE_f = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = 0.5$$

$$\frac{1}{2}\times 0.1\times u^2 = 0.5$$

$$u = \sqrt{10}\ \text{m/s} \quad \text{(Minimum)}$$

Minimum kinetic energy recovered if collision is perfectly inelastic (e = 0)

$$mu = mv_1 + mv_2$$

$$v_1 + v_2 = u \qquad \text{...(iii)}$$

$$e = 0$$

$$\Rightarrow \quad 0 = \frac{v_2 - v_1}{u}$$

$$v_2 = v_1 \qquad \text{...(iv)}$$

From (iii) and (iv)

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

$$KE_f = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = 0.5$$

$$\frac{1}{2}\times m\left(\frac{u^2}{4} + \frac{u^2}{4}\right) = 0.5$$

$$\frac{u^2}{2} = 10$$

$$u = \sqrt{20}\ \text{m/s} \quad \text{(Maximum)}$$

So, $$\frac{u_{\max}}{u_{\min}} = \sqrt{2} = 1.414$$

23. (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

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

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

24. (b)

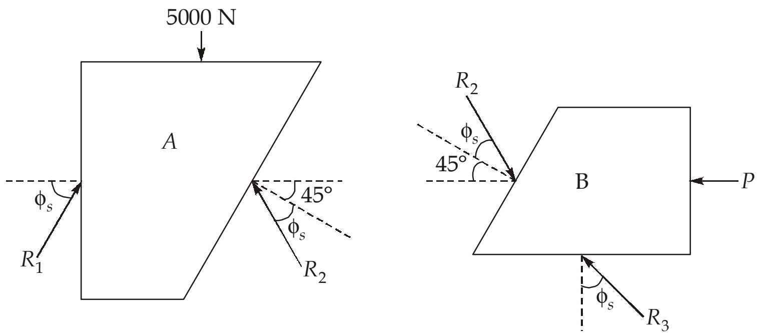
$$mg(\sin\theta + \mu\cos\theta) = 3mg(\sin\theta - \mu\cos\theta)$$

$$(\sin 45° + \mu\cos 45°) = 3(\sin 45 - \mu\cos 45°)$$

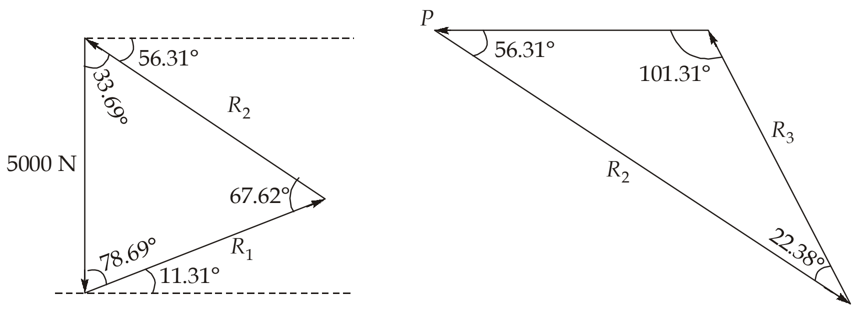
$$\mu = 0.5$$

25. (c)
Coefficient of friction, $\mu_s = 0.2$.
Here the force P is required to maintain the equilibrium. The direction of impending motion of the block A is downwards and that of block B is rightwards.
The free body-diagrams of the block are:

[Angle of friction: $\phi_s = \tan^{-1}\mu$, $\phi_s = \tan^{-1}(0.2)$, $\phi_s = 11.31°$]



Making force triangles for A and B



Applying Lami's theorem for block A

$$\frac{5000}{\sin 67.62°} = \frac{R_1}{\sin 33.69°} = \frac{R_2}{\sin(78.69°)}$$

$$\therefore \quad R_2 = 5000 \times \frac{\sin(78.69°)}{\sin(67.62°)} = 5302.27 \text{ N}$$

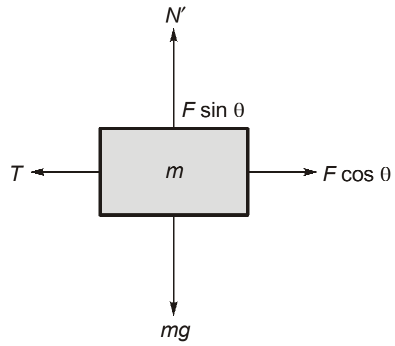
From Lami's theorem for block B

$$\frac{P}{\sin(22.38°)} = \frac{R_3}{\sin(101.31°)} = \frac{R_3}{\sin(56.31°)}$$

$$\therefore \quad P = R_2 \times \frac{\sin(22.38°)}{\sin(101.31°)}$$

$$P = 5302.27 \times \frac{\sin(22.38°)}{\sin(101.31°)} = 2058.81 \text{N}$$

26. (b)



Considering free body diagram

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

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

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

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

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

27. (c)

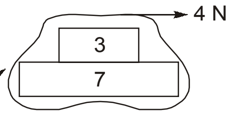
Drawing free body diagram of upper block,

$$10 - \mu_1 mg = m\,a.$$

$$10 - 0.2 \times 2 \times 10 = 2 \times a$$

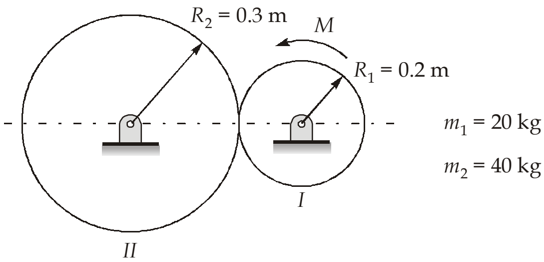
$$a_1 = 3 \text{ ms}^{-2}$$

for the 3 kg block, as frictional reaction from 2 kg will act in right, the 3 kg and 7 kg block will move simultaneously, since the 7 kg block is in contact with zero friction surface. There will be no tendency of relative motion between 3 kg and 7 kg and both will move as a same system due to the action of frictional force acting on the top of 3 kg by the 2 kg block



$$4 = 10a$$
$$a = 0.4$$
$$a_2 = 0.4 \text{ ms}^{-2}$$
$$a_3 = 0.4 \text{ ms}^{-2}$$

28. (b)



$$\text{Moment of inertia, } I_1 = \frac{m_1R_1^2}{2} = \frac{20\times0.2^2}{2} = 0.4 \text{ kgm}^2$$

$$I_2 = \frac{m_2R_2^2}{2} = \frac{40\times0.3^2}{2} = 1.8 \text{ kgm}^2$$

A force of friction F acts between disc I and II which drives disc II.

$$F\times R_2 = I_2\alpha_2 \qquad \text{...(1)}$$
$$R_1\alpha_1 = R_2\alpha_2$$
$$\Rightarrow \quad 0.2\times 8.33 = 0.3\times\alpha_2$$
$$\alpha_2 = 5.55 \text{ m/s}^2$$

Put α_2 value in (1)

We get $F = 33.32$ N

$$M - FR_1 = I_1\alpha_1$$
$$\Rightarrow \quad M - 33.32\times 0.2 = 0.4\times 8.33$$
$$M = 9.996 \simeq 10 \text{ Nm}$$

29. (a)

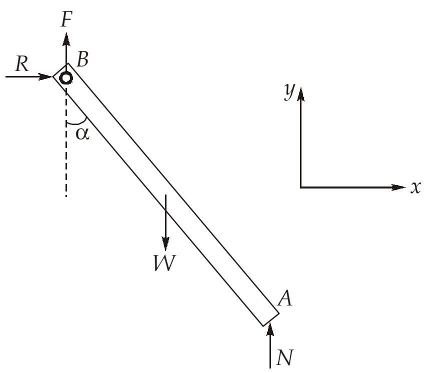
Mass of bar, $m = 4$ kg

Length of bar, $L = 6$ m

The elongation in the spring,

$$x = L - L\cos\alpha \qquad \text{... (i)}$$

Free-body diagram of the bar is given as:



From equilibrium equations,

$\Sigma F_x = 0, \quad R = 0$

$\Sigma F_y = 0, \quad F + N = W$

$\Sigma M_A = 0, \; W\frac{L}{2}\sin\alpha - RL\cos\alpha - FL\sin\alpha = 0$

as $R = 0$

$$W\frac{L}{2}\sin\alpha = FL\sin\alpha$$

$$\therefore \quad F = \frac{W}{2} = \frac{4\times10}{2} = 20\text{ N}$$

∴ Putting this value of F in equation (i),

$$F = k(L)(1-\cos\alpha)$$

$$k = \frac{F}{L(1-\cos\alpha)} = \frac{20}{6(1-\cos30^\circ)}$$

$$k = 24.88\text{ N/m}$$

30. (c)

$$W = f\times s\cos\theta$$

$$W = [200 + \mu(mg + N)]\times 10\times\cos180^\circ]$$

$$W = -[200 + \mu(mg + 100)]\times 10$$

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