CLASS TEST

S.No.: 01DLSK_ME_IJK_070726

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ENGINEERING MECHANICS

MECHANICAL ENGINEERING

Date of Test : 07/07/2026

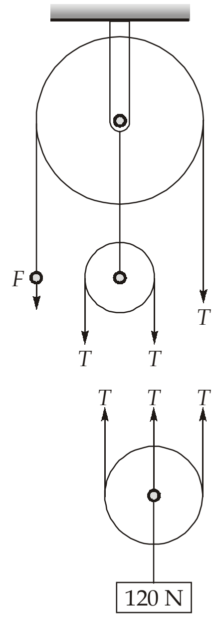
ANSWER KEY

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

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 $3T = 120$

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

2. (b)

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

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

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. (c)

When mass distribution is uniform in a body then its centroid and centre of mass coincides.

Note: In addition to the above it must also be placed under uniform gravitational field.

4. **(c)**

Block slides itself if inclination of plane is greater than angle of repose else it has to be pushed down.

5. **(b)**

Acceleration of the mass is given as:

$$a = \frac{F}{m} \qquad [F = \text{Constant}]$$

Using third equation of kinematics,

$$V^2 = U^2 + 2as \qquad (U = 0)$$

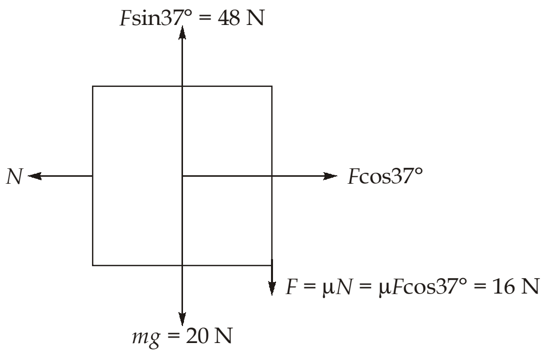
$$V = \sqrt{2as} = \sqrt{2\frac{F}{m}s}$$

Here, it is given that the distance travelled is also constant.

$$V \propto \frac{1}{\sqrt{m}}$$

6. **(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,

$$F_{net,\,y} = ma$$

$$[48 - (20 + 16)] = 2a$$

$$48 - 36 = 2a$$

$$a = \frac{12}{2} = 6\ \text{m/s}^2$$

7. **(b)**

Since both the bodies are revolving with the same time period, therefore their angular speed will also be same.

$$\frac{a_1}{a_2} = \frac{\omega_1^2 r_1}{\omega_2^3 r_2} = \frac{r_1}{r_2} = \frac{5}{10} = \frac{1}{2}$$

8. **(c)**

Angular deceleration of the wheel is given by

$$\alpha = \frac{\omega_o - \omega}{t} = \frac{15 - 0}{5} = 3\ \text{rad/s}^2$$

Torque applied to produce this deceleration is

$$T = I\alpha = 0.3 \times 3 = 0.9 \text{ N-m}$$

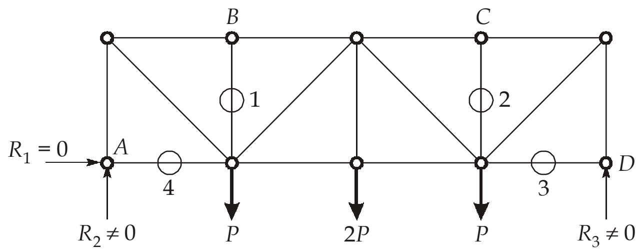
Angle rotated in first 3 seconds is

$$\theta = \omega_o t - \frac{1}{2}\alpha t^2 = 15 \times 3 - \frac{1}{2} \times 3 \times 3^2$$
$$= 31.5 \text{ rad}$$

Work done by the torque in first three seconds,

$$\omega = T\theta = 0.9 \times 31.5 = 28.35 \text{ J}$$

9. **(c)**



- At joint B and C, three members are hinged and out of these three, two members are collinear. So, the force in the third member must be zero to attain static equillibrium. (Members 1 and 2)
- At joint A and B, two perpendicular members are hinged and a force is acting which is along only one member. So, the force in the other member must be zero to attain static equillibrium. (Members 3 and 4)

10. **(d)**

At the instance when the particle changes its direction of motion, the speed will be zero and acceleration will not be zero.

$$s = \frac{t^4}{4} - 128t^2$$

$$v = \frac{ds}{dt} = t^3 - 256t$$

When, $v = 0$, $\quad t^3 - 256t = 0$

$\Rightarrow \quad t(t^2 - 256) = 0$

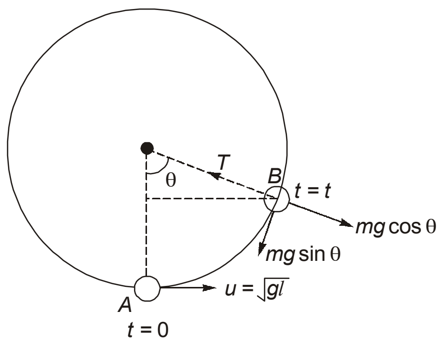
$\Rightarrow \quad t = 0, 16, -16$

$t \neq -16$s (Time is always positive)

$t \neq 0$ s (Because particle starts to move at that moment)

$\Rightarrow \quad t = 16$ seconds

11. **(c)**



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

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

Apply conservation of mechanical energy between points A and B,

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

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

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).

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

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

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

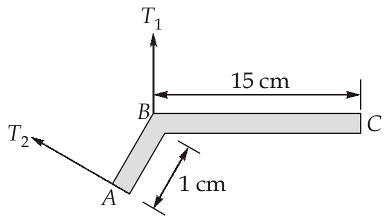
Substituting $\cos\theta = \frac{2}{3}$ in equation (4),

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

12. (b)

Given: Coefficient of friction, $\mu_k = 0.20$, Contact angle, $\theta = \frac{240}{180}\pi = 4.189 \text{ rad}$, 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,

$$\frac{T_2}{T_1} = e^{\mu_k\theta} = e^{0.2\times4.189}$$

$$T_1 = 0.433T_2 \quad ... \text{(ii)}$$

Solving equation (i) and (ii),

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

Taking moment about the point B,

$\Sigma M_B = 0,$

$$-T_2 \times 1 + P \times 15 = 0$$

$$P = \frac{T_2 \times 1}{15} = \frac{1410.93 \times 1}{15} = 94.06 \text{ N}$$

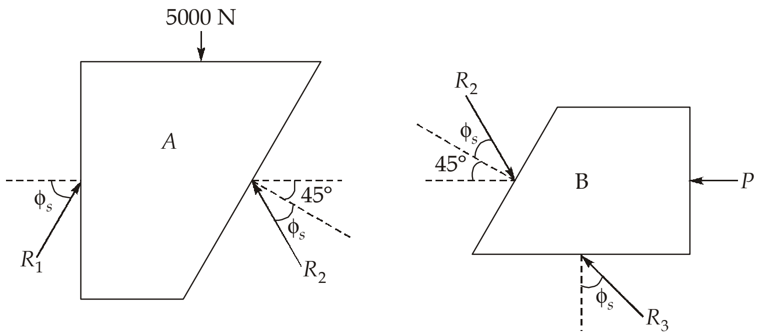
13. (c)

Coefficient of friction, $\mu_s = 0.2$.

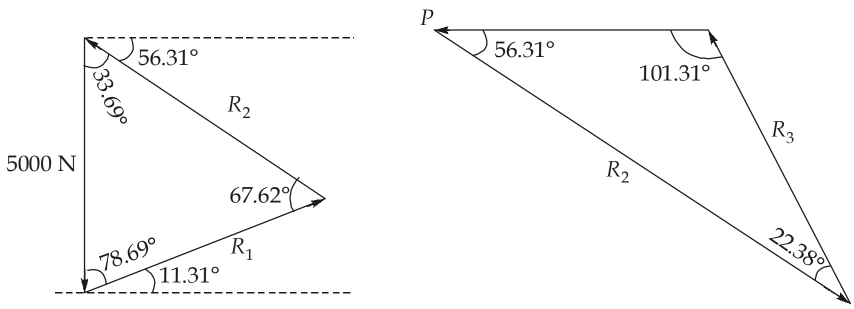
Here the force P is required to maintain the equilibrium. The direction of impending motion of the block A is downwards and that of block B is rightwards.

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

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

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

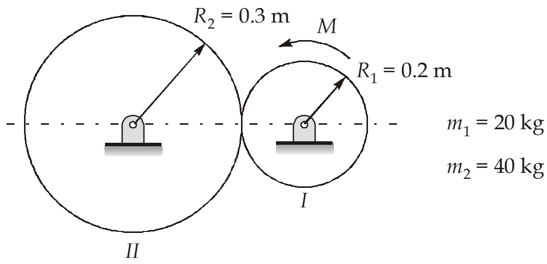
From Lami's theorem for block B

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

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

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

14. (b)



$$\text{Moment of inertia, } I_1 = \frac{m_1 R_1^2}{2} = \frac{20 \times 0.2^2}{2} = 0.4 \text{ kgm}^2$$

$$I_2 = \frac{m_2 R_2^2}{2} = \frac{40 \times 0.3^2}{2} = 1.8 \text{ kgm}^2$$

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

$$F \times R_2 = I_2 \alpha_2 \quad \text{...(1)}$$

$$R_1 \alpha_1 = R_2 \alpha_2$$

$$\Rightarrow \quad 0.2 \times 8.33 = 0.3 \times \alpha_2$$

$$\alpha_2 = 5.55 \text{ m/s}^2$$

Put α_2 value in (1)

We get $\quad F = 33.32$ N

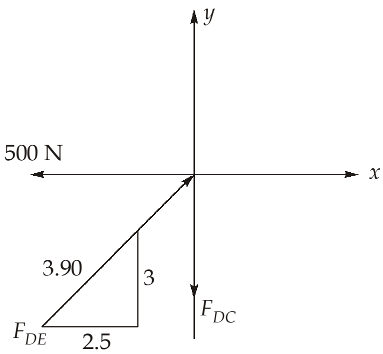
$$M - FR_1 = I_1 \alpha_1$$

$$\Rightarrow \quad M - 33.32 \times 0.2 = 0.4 \times 8.33$$

$$M = 9.996 \simeq 10 \text{ Nm}$$

15. (b)

Beginning by analyzing the equilibrium of joint D.



$\Sigma F_x = 0$

$$F_{DE} \cos\theta - 500 = 0$$

$$F_{DE} = \frac{500}{\cos\theta} = 780 \text{ N}$$

F_{DE} is compressive in nature.

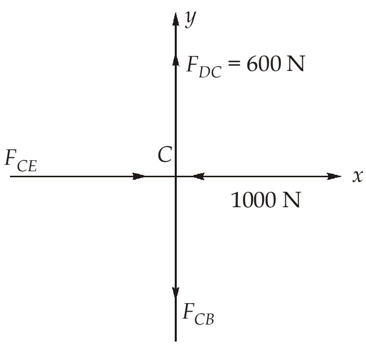
$\Sigma F_y = 0$

$$F_{DC} = F_{DE} \sin\theta$$

$$F_{DC} = 780 \times \frac{3}{3.90} = 600 \text{ N}$$

F_{DC} is tensile in nature.

Free-body diagram of the joint C,



$\Sigma F_x = 0$

$$F_{CE} = 1000 \text{ N}$$

F_{CE} is compressive in nature,

$\Sigma F_y = 0, \quad 600 - F_{CB} = 0$

$$F_{CB} = 600 \text{ N}$$

F_{CB} is tensile in nature.

16. (a)

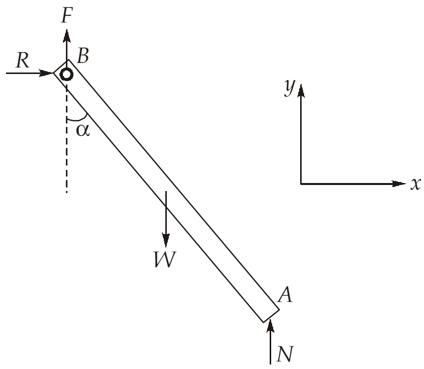
$$\text{Mass of bar, } m = 4 \text{ kg}$$

$$\text{Length of bar, } L = 6 \text{ m}$$

The elongation in the spring,

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

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 $R = 0$

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

$$\therefore \quad F = \frac{W}{2} = \frac{4 \times 10}{2} = 20\text{ N}$$

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

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

$$k = \frac{F}{L(1-\cos\alpha)} = \frac{20}{6(1-\cos 30°)}$$

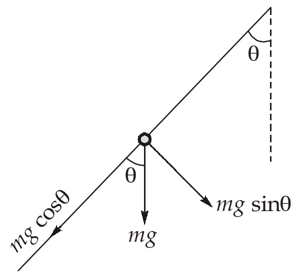
$$k = 24.88\text{ N/m}$$

17. (a)

Value of AB is given as,

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

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,

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

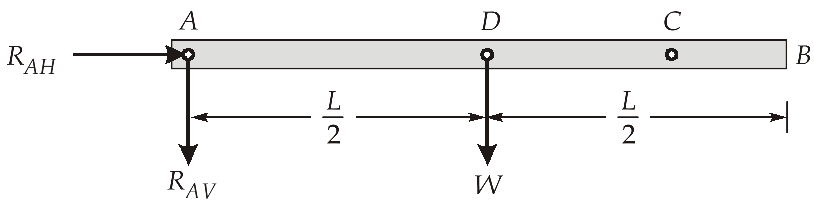
$$AB = \frac{1}{2}at^2$$

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

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

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

18. (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.

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

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

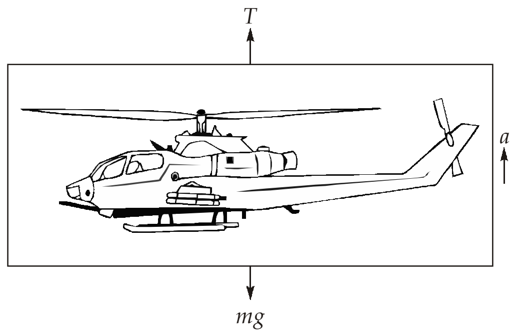
$$\Rightarrow \quad W - R_{AV} = \left(\frac{W}{g}\right) \times \frac{L}{2} \times \frac{3g}{2L}$$

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

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

19. **(b)**

Free-body diagram of the helicopter is given by:



Net force on the helicopter is given as,

$$F_{net} = T - mg = (200 + 2t^3 - 100) \text{ kN}$$

Impulse of the net force is given as

$$I = \int_0^4 F_{net}\,dt = \int_0^4 \left(200 + 2t^3 - 100\right) dt$$

$$= \int_0^4 \left(2t^3 + 100\right) dt = 2\left[\frac{t^4}{4}\right]_0^4 + 100[t]_0^4$$

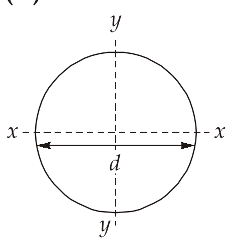
$$= \frac{2}{4}\left[4^4 - 0\right] + 100[4 - 0]$$

$$= 128 + 400 = 528 \text{ kN-s}$$

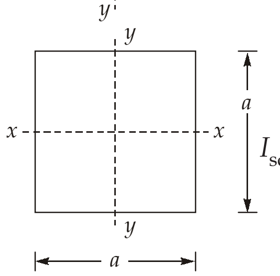
20. **(a)**

The vertical reaction due to weight will be in upwards direction on both the hinges. The horizontal reactions will form an anticlockwise couple which will balance the moment due to weight.

21. **(d)**



$$I_{circle} = I_{xx} = I_{yy} = \frac{\pi}{64} d^4$$



$$I_{square} = I_{xx} = I_{yy} = \frac{a^4}{12}$$

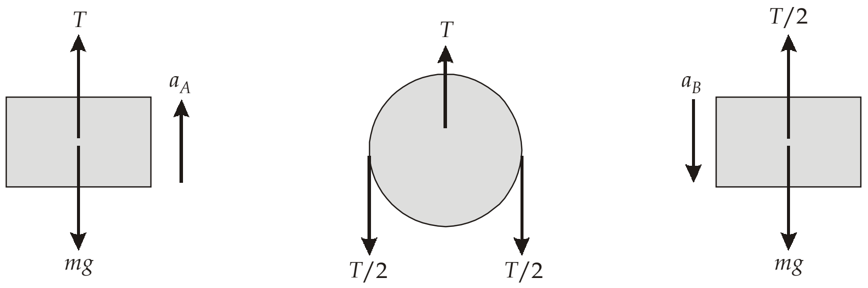
Since both have same area,

$$A = a^2 = \frac{\pi}{4} d^2$$

$$\frac{I_{circle}}{I_{square}} = \frac{\left(\frac{\pi}{64} \cdot d^4\right)}{\left(\frac{a^4}{12}\right)} = \frac{\left(\frac{\pi}{64} d^4\right)}{\frac{1}{12}\left(\frac{\pi}{4} d^2\right)^2} = 0.954929 \approx 0.955$$

22. (d)

Let the a_A and a_B be the acceleration of A and B respectively. Drawing free body diagrams and applying Newton's laws of motion.



Block A **Lower Pulley** **Block B**

$$T - mg = ma_A \quad \text{...(i)}$$

$$mg - \frac{T}{2} = ma_B \quad \text{...(ii)}$$

From constraint equations,

$$a_B = 2a_A \quad \text{...(iii)}$$

Eliminating T from equation (i) and (ii),

$$mg = m(a_A + 2a_B)$$

$$\therefore \quad mg = m\left(\frac{a_B}{2} + 2a_B\right)$$

$$\Rightarrow \quad mg = m\left(\frac{5a_B}{2}\right)$$

$$\Rightarrow \quad a_B = \frac{2g}{5}$$

23. (a)

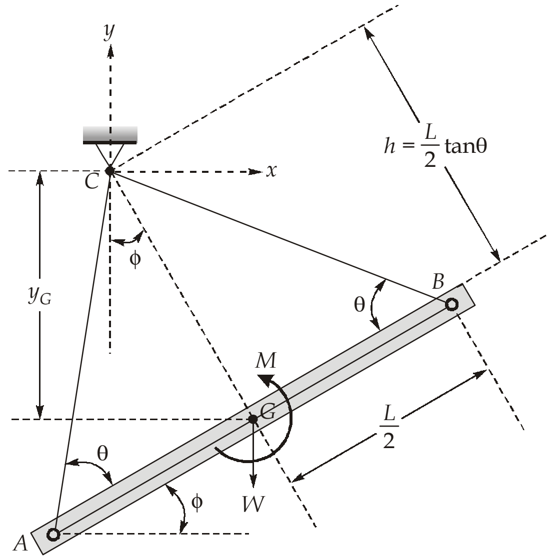
$$\vec{v}_o = v\,\vec{i}$$

$$\vec{v}_D = 0 \qquad \text{[Instantaneous centre of rotation]}$$

$$\vec{v}_B = 2v\,\vec{i}$$

$$|\vec{v}_C| = |\vec{v}_A| = R\sqrt{2}\omega = R\sqrt{2}\left(\frac{v}{R}\right) = \sqrt{2}v$$

24. (a)



Considering the fixed point C as origin of rectangular coordinate system.
Point G:

$$x_G = \frac{L}{2}\tan\theta\sin\phi$$

$$\delta x_G = -h\cos\phi = -\frac{L}{2}\tan\theta\cos\phi$$

$$\Rightarrow \quad \delta x_G = 0$$

and $$\delta y_G = \frac{L}{2}\tan\theta\sin\phi\,\delta\phi$$

Using the method of virtual work;

$(\text{Virtual work})_W + (\text{Virtual work})_M = 0$

$$(-W)(\delta y_G) + (M)(\delta\phi) = 0$$

$$\Rightarrow (-W)\left(\frac{L}{2}\tan\theta\sin\phi\,\delta\phi\right) + M\,\delta\phi = 0$$

$$\Rightarrow \quad -\frac{WL}{2}\tan\theta\sin\phi + M = 0$$

$$\Rightarrow \quad M = \frac{WL}{2}\tan\theta\sin\phi$$

25. (b)

Under static equillibrium:

$\Sigma F_V = 0;$ $\quad N_B = W$

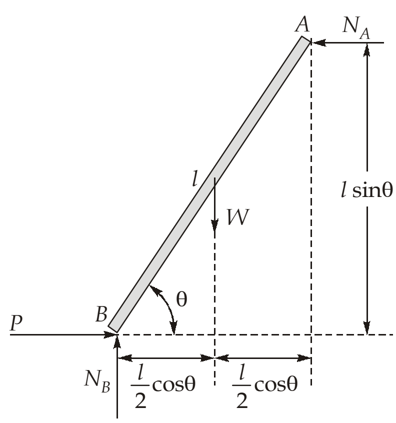
$\Sigma F_H = 0;$ $\quad N_A = P$

$\Sigma M_B = 0;$ $\quad N_A\, l\sin\theta = W\frac{l}{2}\cos\theta$

$$\Rightarrow \quad P\sin\theta = \frac{W}{2}\cos\theta$$

$$\Rightarrow \quad W = 2P\tan\theta = 2(50)\tan 60°$$

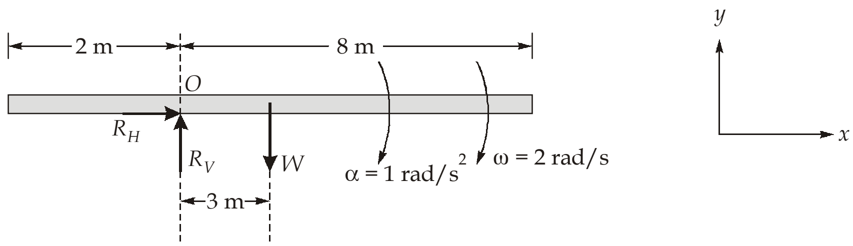
$$= 100\sqrt{3}\text{ N}$$



26. (c)

Mass of rod, $m = 5$ kg

Length of rod, $L = 10$ m



$\Sigma F_{ext,x} = ma_{cm,x}$

$$\Rightarrow \quad R_H = mr_{cm}\,\omega^2 = 5 \times 3 \times 2^2 = 60 \text{ N}$$

$\Sigma F_{ext,y} = ma_{cm,y}$

$$\Rightarrow \quad mg - R_V = mr_{cm}\,\alpha$$

$$R_V = mg - mr_{cm}\,\alpha$$

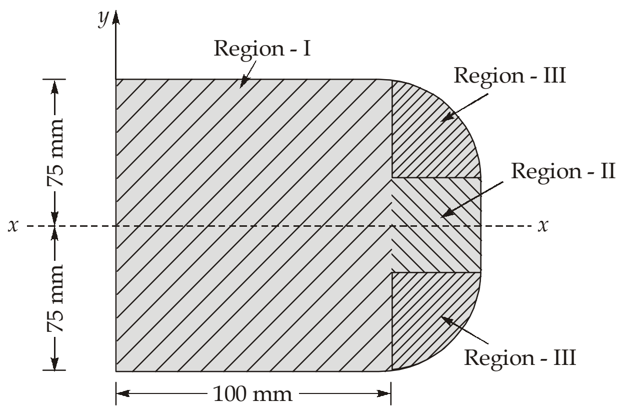
$$= 5 \times (9.81) - 5 \times 3 \times 1 = 34.05 \text{ N}$$

Net reaction at hinge, $R = \sqrt{R_H^2 + R_V^2} = \sqrt{(60)^2 + (34.05)^2}$

$$= 68.9884 \text{ N} \approx 69 \text{ N}$$

27. (a)

For simplicity, dividing it into 3 regions.



$$I_{(\text{region-I})yy} = \frac{1}{12} \times 150 \times (100)^3 + 150 \times 100 \times \left(\frac{100}{2}\right)^2$$

$$= 500 \times 10^5 \text{ mm}^4$$

$$I_{(\text{region-II})yy} = \frac{1}{12} \times 50 \times (50)^3 + 50 \times 50 \times \left(100 + \frac{50}{2}\right)^2$$

$$= 395.83333 \times 10^5 \text{ mm}^4$$

Region-III combined together can be treated as semi-circle.

$$I_{(CG)_y} = \frac{\left(a\pi^2 - 64\right)r^4}{y2\pi} \simeq 0.11 \text{ r}^4$$

$$I_{yy} = 0.11r^4 + \frac{\pi r^2}{2}\left(100 + \frac{4r}{3\pi}\right)^2$$

where, $r = 50$ mm

So, $(I_{yy})_{III} = 583.92 \times 10^5 \text{ mm}^4$

$$I_{yy} = I_{(\text{region-I})_{yy}} + I_{(\text{region-II})_{yy}} + I_{(\text{region-III})_{yy}}$$

$$= (500 + 395.83333 + 583.92) \times 10^5$$

$$I_{yy} = 1479.75 \times 10^5 \text{ mm}^4$$

Total area moment by inertia about y-axis of the section is 1479.75×10^5 mm^4.

28. (b)

Given: $P = 5t$, $\mu_s = 0.5$, $\mu_k = 0.4$, $N = mg = 100$ N

$$(f_s)_{max} = \mu_s N = 0.5 \times 100 = 50 \text{ N}$$

P becomes 50 N at $t = 10$ s

$\Rightarrow$ From $t = 0$ to $t = 10$s, there is no motion.

From $t = 10$s to $t = 20$s, there will be kinetic friction.

$$f_k = \mu_k N = 0.4 \times 100 = 40 \text{ N}$$

$$P(t = 20\text{s}) = P_{max} = 100 \text{ N}$$

$$P(t = 10\text{s}) = P_{min} = 50 \text{ N}$$

Since, the force P increases linearly with time during time, $t = 10$s to $t = 20$s, so average concept is valid here.

$$P_{avg} = \frac{P_{max} + P_{min}}{2} = \frac{100 + 50}{2} = 75 \text{ N}$$

Average resultant force $= P_{avg} - f_k = 75 - 40 = 35$ N

Average acceleration $= \dfrac{35 \times 9.81}{100} = 3.4335 \text{ m/s}^2$

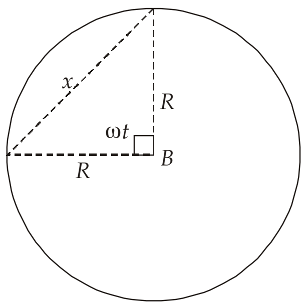
$$v = u^{o} + at$$

$$= at = (3.4335) \times (20 - 10) = 34.335 \text{ m/s}$$

$$\approx 34.34 \text{ m/s}$$

29. (d)

Angle rotated in time 't' is given as



$$\theta = \omega t$$

$$\cos\omega t = \frac{R^2 + R^2 - x^2}{2R^2}$$

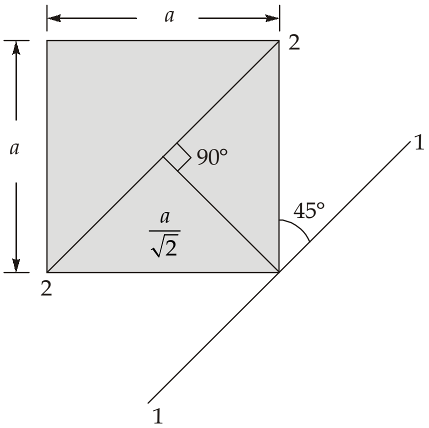
$$2R^2 \cos\omega t = 2R^2 - x^2$$

$$x^2 = 2R^2(1 - \cos\omega t)$$

$$x^2 = 2R^2 \times 2\sin^2\frac{\omega t}{2}$$

$$x = 2R\sin\frac{\omega t}{2}$$

30. (a)



$$I_{22} = \frac{Ma^2}{12}$$

Using parallel-axis theorem,

$$I_{22} = I_{22} + M\left(\frac{a}{\sqrt{2}}\right)^2$$

$$= \frac{Ma^2}{12} + \frac{Ma^2}{2}$$

$$= \frac{Ma^2 + 6Ma^2}{12} = \frac{7Ma^2}{12}$$

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