CLASS TEST

S.No.: 03DLSKCE_IJKL_290626

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ENGINEERING MECHANICS

CIVIL ENGINEERING

Date of Test : 29/06/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

As per given information,

$$h = 40 \text{ m}, u = 50 \text{ m/s}$$

Let the speed be 'v' when it strikes to the ground

Apply law of conservation of energy,

$$mgh + \frac{1}{2}mu^2 = \frac{1}{2}mv^2$$

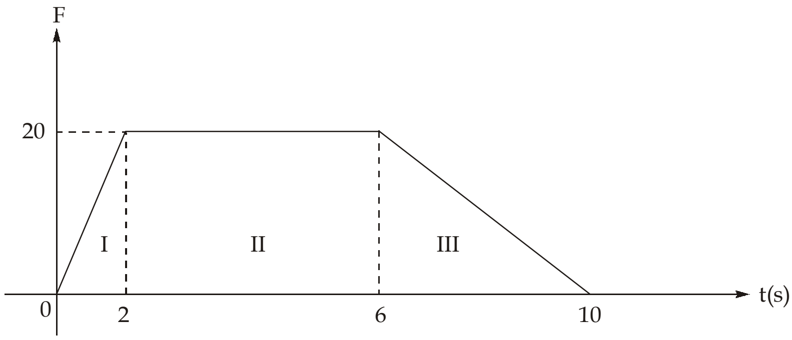
$$m \times 10 \times 40 + \frac{1}{2} \times m \times (50)^2 = \frac{1}{2} \times m \times v^2$$

$$400 + 1250 = \frac{v^2}{2}$$

$$v = 57.44 \text{ m/s}$$

2. (d)

As per given information,



$$\text{Impulse} = \int_{t_1}^{t_2} F(t)dt = \text{Area under (F - t) curve}$$

$$\text{Impulse} = \text{Area (I + II + III)}$$

$$= \frac{1}{2} \times 2 \times 20 + 4 \times 20 + \frac{1}{2} \times 4 \times 20$$

$$= 140 \text{ kg.m/s or Ns}$$

3. (d)

The block is displaced 2.5 m towards left,

Let the velocity of the body be v at mean position

As dissipative force, (friction = 0)

$$(\text{K.E.})_{max} = (\text{P.E.})_{max}$$

$$\frac{1}{2}mv_{max}^2 = \frac{1}{2} \times k_1 \times x^2 + \frac{1}{2} \times k_2 \times x^2$$

$$mv_{max}^2 = k_1 \times x^2 + k_2 x^2$$

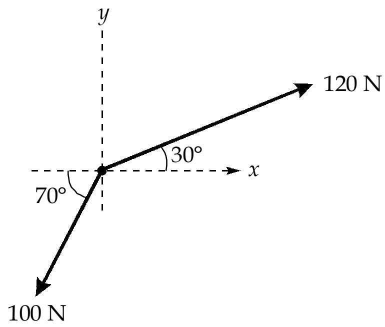
Substituting the given value,

$$100 \times mv_{max}^2 = 40x^2 + 60x^2$$

$$100\, mv_{max}^2 = 100x^2$$

$$v_{max} = x = 2.5 \text{ m/s}$$

4. (c)



$$\Sigma F_x = 120 \cos 30° - 100 \cos 70° = 69.72 \text{ N}$$

$$\Sigma F_y = 120 \sin 30° - 100 \sin 70° = -33.969 \text{ N}$$

$$\text{Resultant force, } R = \sqrt{(F_x)^2 + (F_y)^2}$$

$$= \sqrt{(69.72)^2 + (-33.969)^2} = 77.55 \text{ N} \simeq 78 \text{ N}$$

5. (a)

Using energy conservation

$$(PE)_A + (KE)_A = (PE)_B + (KE)_B \qquad \text{[No energy loss due to smooth surface]}$$

$$mg \times 12 + \frac{1}{2} m \times 0^2 = mg \times 8 + \frac{1}{2} m V_B^2$$

$$\frac{mg \times 4 \times 2}{m} = V_B^{\,2}$$

$$V_B = \sqrt{8 \times 9.81} = 8.859 \text{ m/s}$$

6. (b)

$$R_2 \cos 45° = R_1$$

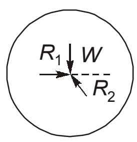
$$R_2 \sin 45° = W$$

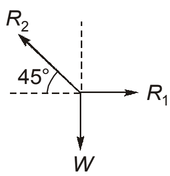
$\Rightarrow$ $$R_2 = W\sqrt{2}$$

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

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

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





7. (d)

8. **(b)**

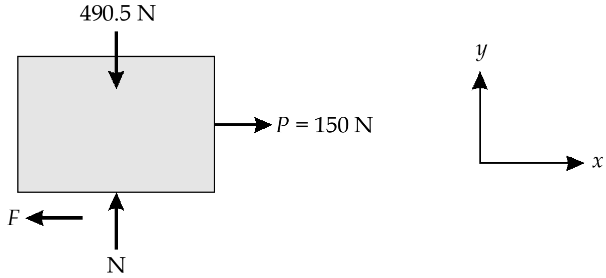
When body is at rest, for equilibrium,

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

Applied force, $P = 150$ N

Maximum static friction force,

$$F_{max} = \mu_s N$$
$$= 0.5\ (490.5)$$
$$= 245.25 \text{ N}$$

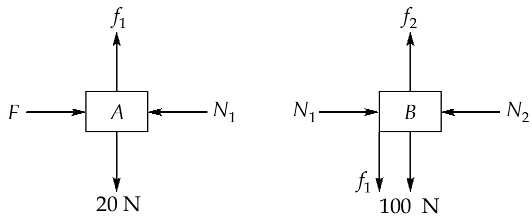


Because $P < F_{max}$, we conclude that the block is in static equilibrium and correct value of friction force is,

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

9. **(b)**

The *FBD* of blocks *A* and *B* are,



So, $f_1 = 20$ N

f_2(friction on *B* due to wall) = 100 + f_1 = 120 N

10. **(a)**

Given: $\vec{F} = 10\hat{i} + 5\hat{j} + \hat{k}$ (N)

$$x = \sqrt{106} \text{ m}$$

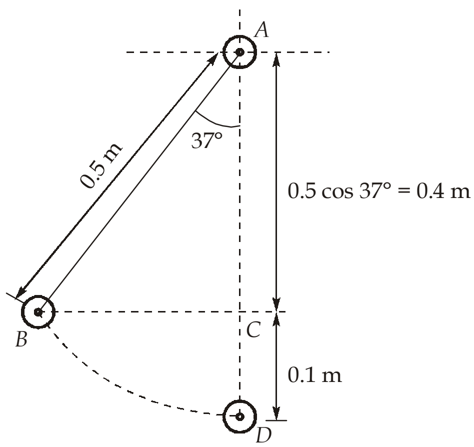
Now, $\vec{A} \times \vec{B} = (3\hat{i} + 4\hat{j}) \times (3\hat{j} + \hat{k}) = 4\hat{i} - 3\hat{j} + 9\hat{k}$

Now, $W = \left[(10\hat{i} + 5\hat{j} + \hat{k}) \times \sqrt{106}\right] \cdot \dfrac{(4\hat{i} - 3\hat{j} + 9\hat{k})}{\sqrt{4^2 + 3^2 + 9^2}}$

or $W = 40 - 15 + 9$

$\therefore$ $W = 34$ Nm

11. **(c)**



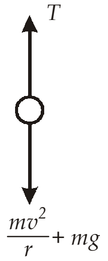
$$CD = AD - AC$$
$$= 0.5 - 0.5 \cos 37°$$
$$= 0.1 \text{ m}$$

Applying energy conservation between B and D

$$mg \times CD = \frac{1}{2}mv^2 \qquad \because V = \text{Velocity at } D$$

Let $g = 10 \text{ m/s}^2$

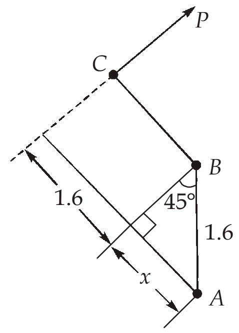
$$10 \times 0.1 = 0.5v^2$$
$$v^2 = 2$$



At point 'D'

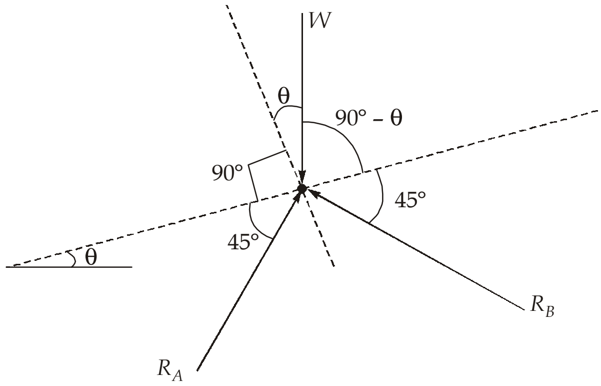
$$\text{Tension, } T = \frac{mv^2}{r} + mg$$
$$T = m\left(\frac{v^2}{r} + g\right) = 0.1\left(\frac{2}{0.5} + 10\right)$$
$$T = 1.4 \text{ N}$$

12. **(a)**



$$\text{Moment of P about A} = P \times (1.6 + x)$$
$$\sin 45° = \frac{x}{1.6}$$
$$x = 1.6 \sin 45° = 1.1314 \text{ m}$$
$$M_A = 30 \times (1.6 + 1.1314) = 81.9 \text{ N-m}$$

13. (a)



Apply Lami's theorem:

$$\frac{R_A}{\sin(135° - \theta)} = \frac{R_B}{\sin(135° + \theta)}$$

Given: $R_A = 2\,R_B$

$\Rightarrow$ $2\sin(135 + \theta) = \sin(135 - \theta)$

$\Rightarrow 2[\sin 135° \cos\theta + \cos 135° \sin\theta] = [\sin 135° \cos\theta - \cos 135° \sin\theta]$

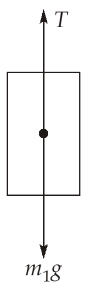
$\Rightarrow$ $3\cos 135° \sin\theta = -\sin 135° \cos\theta$

$\Rightarrow$ $\tan\theta = -\frac{1}{3}\tan 135°$

$\theta = 18.43°$

14. (b)

Cylinder

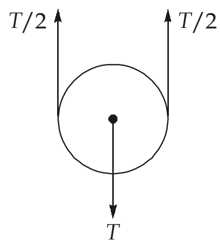


From Newton's first law,

$m_1g - T = 0$

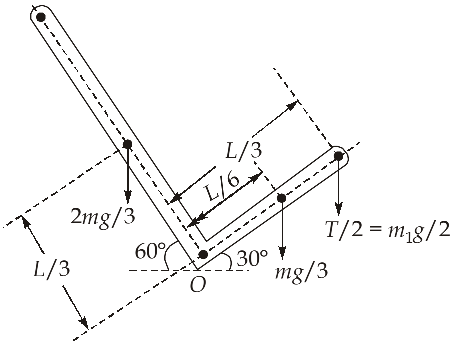
$T = m_1g$

Pulley



$$\frac{T}{2} = \frac{m_1 g}{2}$$

To cause loss of contact at A, reaction at *A* will be zero.



$\Sigma M_o = 0$

$$\frac{2mg}{3} \times \frac{L}{3}\cos 60° - \frac{mg}{3} \times \frac{L}{6}\cos 30° - \frac{T}{2} \times \frac{L}{3}\cos 30° = 0$$

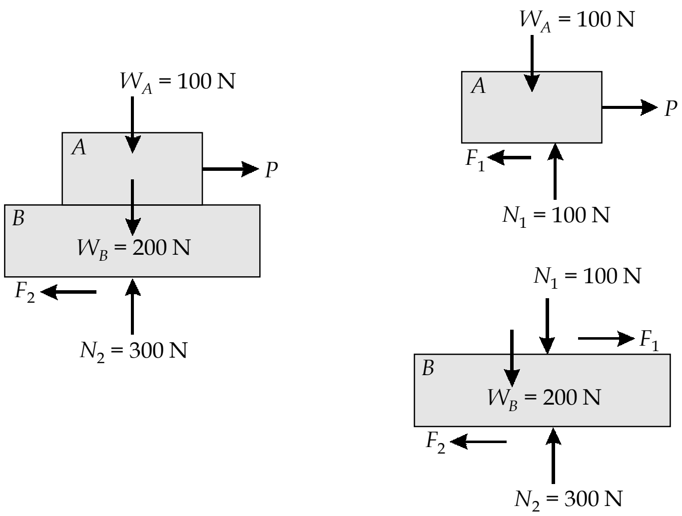
$$\Rightarrow \quad \frac{2mg}{9} L\cos 60° = \frac{m}{18} gL\cos 30° + \frac{m_1 g}{2} \times \frac{L}{3}\cos 30°$$

$$\Rightarrow \quad \frac{2m}{9}\cos 60° = \frac{m}{18}\cos 30° + \frac{m_1}{6}\cos 30°$$

$$m_1 = 0.436 \text{ m}$$

15. **(c)**

Given,



Assume impending sliding at surface, 1

$$F_1 = (F_1)_{max} = (\mu_s)N_1 = 0.2 \times 100 = 20 \text{ N}$$

From FBD of block 'A'

$\Sigma F_x = 0, \qquad P - F_1 = 0$

$$P = 20 \text{ N}$$

Assume impending sliding at surface force 2 only

$$F_2 = (F_2)_{max} = \mu_s N_2 = 0.1 \times 300 = 30 \text{ N}$$

From FDB,

$$P - F_2 = 0$$

$$P = 30 \text{ N}$$

P = 20 N will cause motion to impend at surface 1 and that P = 30 N will cause motion to impend at surface 2, therefore the largest force that can be applied without causing either block to move is P = 20 N.

16. (a)

$$\text{Let momentum, } P = at^2 + bt + c$$

$$\text{force, } F = \frac{dP}{dt} \text{ at } t = 0 \text{ is 80 N}$$

$$F = 2a \times 0 + b$$

$$80 = b$$

$$\Rightarrow \quad b = 80$$

$$\text{Now, at } t = 2 \text{ sec}$$

$$F = 2a \times 2 + 80$$

$$\frac{480 - 80}{4} = a$$

$$a = 100$$

$$F = 2at + 80$$

$$\text{Now, } F = 200t + 80$$

$$\text{Acceleration} = \frac{F}{m} = \frac{200t + 80}{5} = 40t + 16$$

$$\text{Acceleration} = \frac{dv}{dt}$$

$$dv = (40t + 16)dt$$

$$\int_0^v dv = \int_0^5 (40t + 16)\,dt$$

$$v - 0 = \left[40 \times \frac{t^2}{2} + 16t\right]_0^5$$

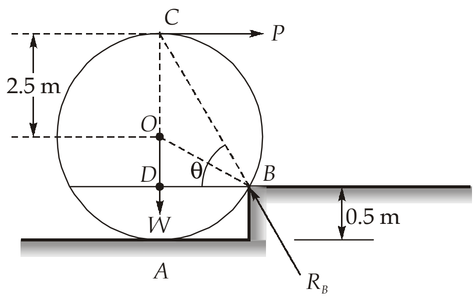
$$v = 40 \times \frac{5^2}{2} + 16 \times 5$$

$$v = 25 \times 20 + 80$$

$$v = 580 \text{ m/s}$$

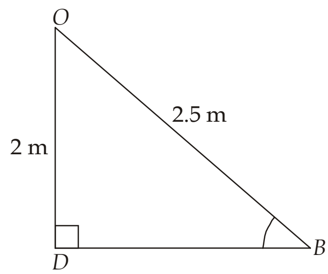
17. (b)

For a body under three forces to be in equilibrium, these forces must be coplanar and concurrent. So, force P, weight of cylinder W and reaction at $B(R_B)$ passes through the same point that's the upper most point of cylinder.



In ΔOBD,

$$OB^2 = OD^2 + DB^2$$
$$2.5^2 = (2.5 - 0.5)^2 + DB^2$$
$$DB^2 = 2.25$$
$$DB = 1.5 \text{ m}$$

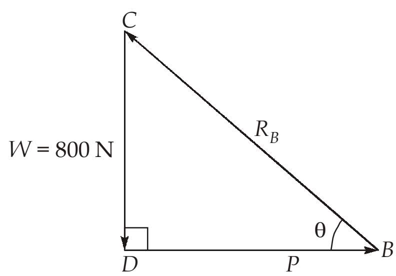


In ΔBCD,

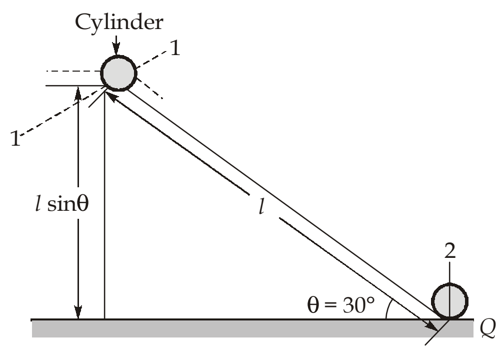
$$\tan\theta = \frac{2.5+2}{1.5} = \frac{4.5}{1.5} = 3$$
$$\theta = 71.565°$$
$$\frac{W}{P} = \tan\theta$$
$$\Rightarrow \quad \tan\ 71.565° = \frac{800}{P}$$
$$\Rightarrow \quad P = \frac{800}{3} = 266.67 \text{ N}$$

Alternate: Taking moment about B,

$$P \times CD = W \times DB$$
$$P = \frac{800 \times 1.5}{4.5}$$
$$P = \frac{800}{3} = 266.67 \text{ N}$$



18. (d)



Cylinder rolls without slipping with angular speed $\omega = \frac{v}{r}$ about its axis.

By energy conservation,

$$(\text{KE})_{1-1} + (\text{PE})_{1-1} = (\text{KE})_{2-2} + (\text{PE})_{2-2}$$

$$0 + mgl\sin\theta = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + 0$$

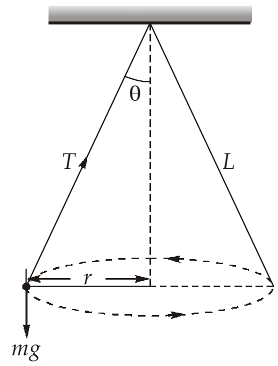
$$mgl\sin\theta = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mR^2\right)\omega^2 = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$mgl\sin\theta = \frac{3}{4}mv^2$$

$$v = \sqrt{\frac{4}{3}gl\sin\theta} = \sqrt{\frac{4}{3}\times 10\times 2\times \sin 30°}$$

$$v = 3.65 \text{ m/s}$$

19. (b)



$$\sin\theta = \frac{r}{L}$$

(a) Tension T along the string

(b) The weight mg vertically downwards.

In radial direction,

$$T\sin\theta = \frac{mv^2}{r}$$

In vertical direction, $T\cos\theta = mg$

Equation (i) and (ii)

$$\tan\theta = \frac{v^2}{rg}$$

$$v = \sqrt{(rg\tan\theta)} = \sqrt{(rg)\times\left(\frac{r}{\sqrt{L^2 - r^2}}\right)}$$

$$v = \frac{r\sqrt{g}}{(L^2 - r^2)^{1/4}}$$

By equation (ii), $$T = \frac{mg}{\cos\theta} = \frac{mgL}{(\sqrt{L^2 - r^2})}$$

$$T = \frac{mgL}{\left(L^2 - r^2\right)^{1/2}}$$

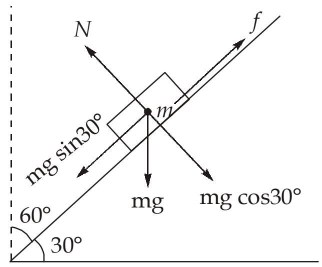
20. (c)

$$\text{Normal reaction, } N = mg\cos 30°$$
$$\text{friction force, } f = \mu N$$
$$f = \mu mg\cos 30°$$

Now, resultant force in downward direction will be = (mg sin30° – μmg cos30°)

We known that,

$$a = \frac{F}{m} = \frac{m(g\sin 30° - \mu g\cos 30°)}{m}$$



$$\frac{dv}{dt} = g(0.5 - 0.866 \times 3x)$$

$$v\frac{dv}{dx} = g(0.5 - 0.866 \times 3x)$$

Given, $v_i = 0,\ v_f = 0$

Integrating, $$\int_0^0 v\,dv = g\int_0^x (0.5 - 0.866 \times 3x)\,dx$$

$$\left[\frac{v^2}{2}\right]_0^0 = g\left[0.5x - \frac{0.866}{2} \times 3x^2\right]_0^x$$

$$0 = 0.5x - 0.433 \times 3x^2$$

$$0.433 \times 3x^2 = 0.5x$$

$$x = \frac{0.5}{0.433 \times 3}$$

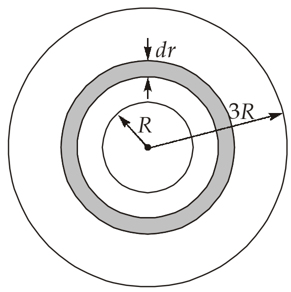
$$x = 0.3849 \text{ m}$$

21. (a)

Given that, $m = 20$ kg, $r_i = 0.1$ m $= R$, $r_0 = 0.3$ m $= 3R$

$$\text{Cross-section area} = \pi[(3R)^2 - R^2] = 8\pi R^2$$

Mass of small strip of thickness 'dr' at a distance 'r' from centre.



$$dm = \frac{m \times 2\pi r dr}{8\pi R^2}$$

We know that, $$I = \int_R^{3R} dm\cdot r^2$$

$$I = \int_R^{3R} \frac{m \times 2\pi r dr \times r^2}{8\pi R^2} = \frac{m}{4R^2} \times \left[\frac{r^4}{4}\right]_R^{3R}$$

$$= \frac{m}{4 \times 4R^2} \times (81R^4 - R^4) = \frac{20}{4} mR^2 = 5\,mR^2$$

$$(\text{K.E.})_{total} = (\text{K.E.})_{rotational} + (\text{K.E.})_{translation}$$

$$\text{K.E.} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}m \times 9R^2\omega^2 + \frac{1}{2}I\omega^2 = \frac{9}{2}mR^2\omega^2 + \frac{5}{2}mR^2\omega^2$$

$$\text{K.E.} = 7\, mR^2\omega^2$$

$$62.5 = 7 \times 20 \times (0.1)^2 \times \omega^2$$

$$\omega = 6.6815 \text{ rad/s}$$

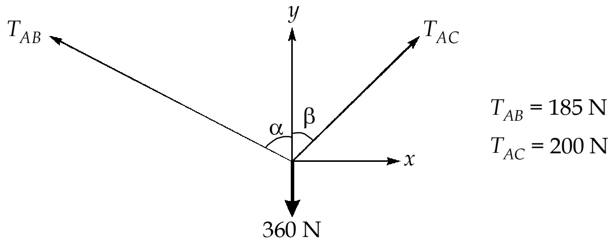
$$v = 3R\omega = 3 \times 0.1 \times 6.6815$$

Velocity of centre of mass, $v = 2$ m/s

Note: for rolling without slipping, $v = r\omega$, $v = 3R\omega$

22. (a)

As per given condition,



$$T_{AB} \sin\alpha = T_{AC} \sin\beta$$

$$\sin\alpha = \frac{200}{185}\sin\beta \quad \text{...(i)}$$

$$T_{AB}\cos\alpha + T_{AC}\cos\beta = 360$$

$$\cos\alpha = \frac{360}{185} - \frac{200}{185}\cos\beta \quad \text{...(ii)}$$

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

$$1 = \left(\frac{200}{185}\right)^2 + \left(\frac{360}{185}\right)^2 - \left(2 \times \frac{360 \times 200}{185^2}\cos\beta\right)$$

$$2 \times \frac{360 \times 200}{185^2}\cos\beta = 3.955$$

$$\cos\beta = 0.9401$$

$$\beta = 19.9° \simeq 20°$$

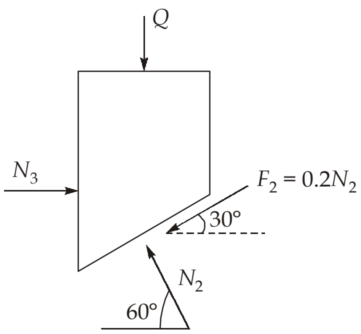
$$\sin\alpha = \frac{200}{185}\sin 20°$$

$$\alpha = 21.7°$$

23. (d)

From Newton's first law,

$\Sigma F_y = 0$



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

$$Q = 0.766\ N_2$$

$\Sigma F_X = 0$

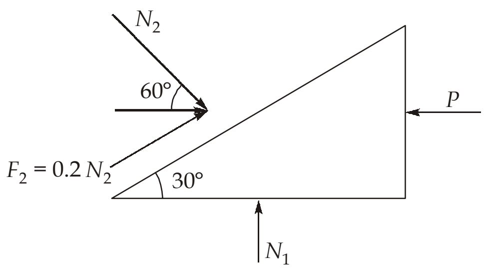
$N_2 \cos 60° + 0.2N_2 \cos 30° - P = 0$

$$P = 0.673\ N_2$$

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

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

$$\alpha = 0.9$$



24. **(a)**

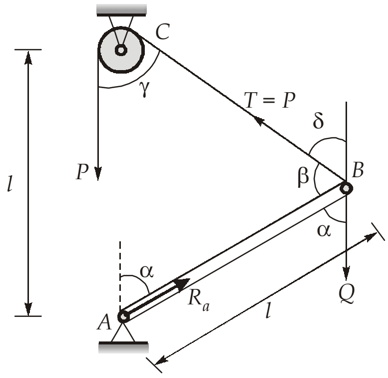
There are three forces acting on the bar AB; pull Q at B, tension in string T and reaction at point A i.e. R_a.

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,



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

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

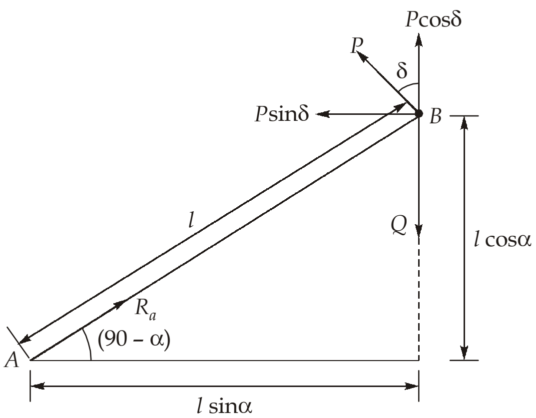
$$P\sin(180° - \beta) = Q\sin\alpha$$

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

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

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

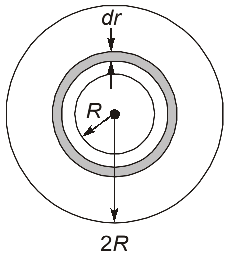
or $$\sin\frac{\alpha}{2} = \frac{P}{2Q}$$



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

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

25. (b)



$\therefore \quad I$ = Moment of inertia of disc

Total mass m is contained in area $3\pi R^2$

Let dm be the mass in area $2\pi r\,d\,r$

$$\therefore \quad dm = \frac{m \times 2\pi r dr}{3\pi R^2}$$

$$I = \int_R^{2R} dm\, r^2$$

$$\therefore \quad I = \frac{5}{2} mR^2$$

$$\text{K.E.} = (\text{K.E.})_{\text{translation}} + (\text{K.E.})_{\text{rotation}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

But $\quad V = 2R\omega$

$$\therefore \quad \text{K.E.} = \frac{1}{2}mv^2 + \frac{1}{2} \times \frac{5R^2}{2} \times \frac{V^2}{4R^2} = \frac{1}{2}mv^2 + \frac{5}{16}mv^2$$

$$\text{K.E.} = \frac{8mv^2 + 5mv^2}{16} = \frac{13}{16}mv^2 = \frac{13}{16} \times 5 \times (2)^2$$

$$\therefore \quad \text{K.E.} = 16.25 \text{ J}$$

26. (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

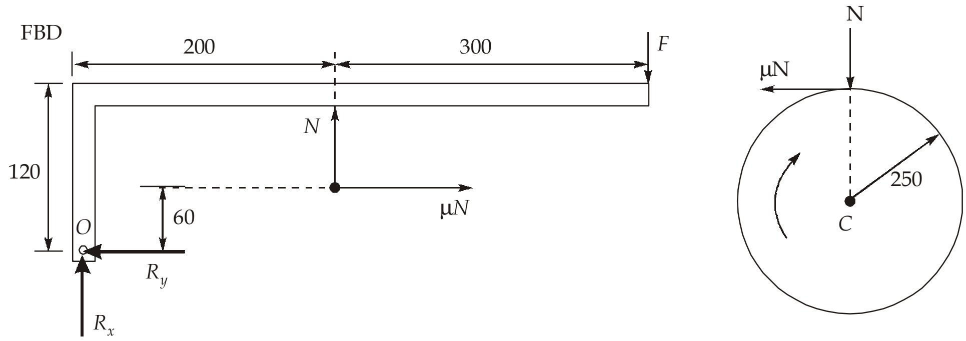
$(N - mg) \times dt = m \times 0 - (-m \times 10)$

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

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

Force of interaction, $N = 1100$ N

27. (a)



For the drum, about C

$$\mu N \times 0.250 = 30$$

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

For the link,

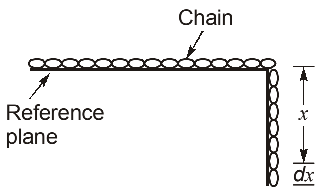
$\Sigma T_{net\_O} = 0$: $\mu N \times 60 + F \times 500 = N \times 200$

$$F = \frac{N \times 200 - \mu N \times 60}{500}$$

$$F = \frac{400 \times 200 - 0.3 \times 400 \times 60}{500}$$

$$F = 145.6 \text{ N}$$

28. (d)



The potential energy of $\frac{l}{3}$ of the chain that overhangs is

$$u_1 = \int_0^{l/3} -\frac{mgx}{l} dx = \frac{-mgl}{18}$$

The potential energy of the full chain when it completely slips off the table is

$$u_2 = \int_0^{l} -\frac{mgx}{l} dx = \frac{-mgl}{2}$$

$$\text{The loss in } PE = \frac{-mgl}{18} - \left(\frac{-mgl}{2}\right) = \frac{4mgl}{9}$$

This should be equal to gain in kinetic energy, but the initial kE is zero. Hence this is the kE when the chain completely falls off the table.

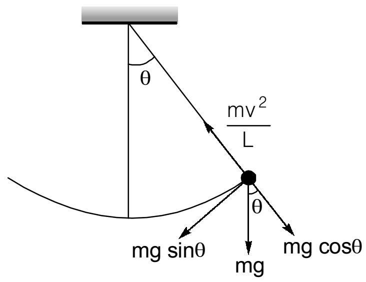
29. (d)

Using conservation of angular momentum,

$$MR^2\omega = \left(MR^2 \times \frac{8\omega}{9}\right) + \left(\frac{M}{8} \times \frac{9R^2}{25} \times \frac{8\omega}{9}\right) + \left(\frac{M}{8} \times x^2 \times \frac{8\omega}{9}\right)$$

$$\therefore \quad x = \frac{4R}{5}$$

30. (a)



$$\Rightarrow \quad T - \text{mg}\cos\theta = \frac{mv^2}{L}$$

$$\Rightarrow \quad T = m\left(g\cos\theta + \frac{v^2}{L}\right)$$

■■■■