CLASS TEST

S.No.: 04SKCE_OPQ_22092024

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ENGINEERING MECHANICS

CIVIL ENGINEERING

Date of Test : 22/09/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

The reaction on the block (R) = 20 kgf

The horizontal force needed to move the block

$= \mu R = 0.22 \times 20$

$= 4.4$ kgf

2. (d)

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

at $t = 3$ sec.

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

3. (b)

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

$$\omega_0 = 0$$

$$\theta = \frac{1}{2} \times 3 \times 10^2 = 150 \text{ rad}$$

$$\therefore \text{ Number of revolutions } = \frac{150}{2\pi} = 23.87$$

4. (d)

$$T = \frac{2m_1 m_2}{m_1 + m_2} g = \frac{2 \times 21 \times 28}{21 + 28} g = 24 \text{ gm wt}$$

5. (c)

For perfectly elastic collision $e = 1.0$

For perfectly inelastic collision, $e = 0$

6. (a)

Velocity $v = 60$ kmph $= 16.67$ m/s

Using energy principle

$$\frac{1}{2} mv^2 = \text{F.S.}$$

$$S = \frac{mv^2}{2F} = \frac{1200 \times (16.67)^2}{2 \times 4.5 \times 1000} = 37.05 \text{ m}$$

7. (c)

The velocity of block embedded with bullet

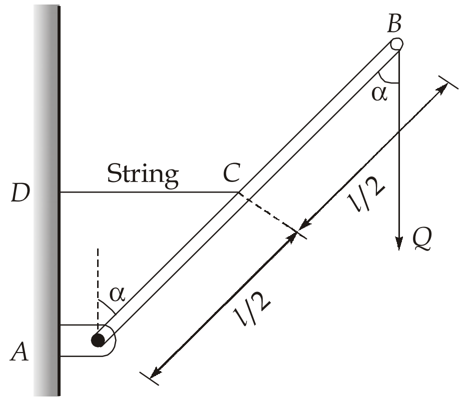
$$v = \frac{401 \times 0.01}{4 + 0.01} = 1 \text{ m/s}$$

Kinetic energy loss $= kE_i - kE_f$

$$= \frac{1}{2} \times 0.01 \times 401^2 - \frac{1}{2} \times 4.01 \times 1^2$$

$= 802$ N – m

8. (b)



Given tension developed in the string = S

Taking moments about A

$$\Sigma M_A = 0$$

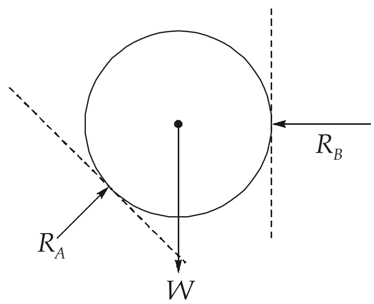
$$\Rightarrow \quad S \times \frac{l}{2}\cos\alpha = Ql\sin\alpha$$

$$\Rightarrow \quad S = \frac{Ql\sin\alpha}{\frac{l}{2}\cos\alpha}$$

$$\Rightarrow \quad S = 2\,Q\tan\alpha$$

9. (d)

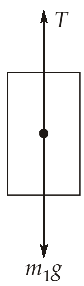
FBD of cylinder



10. (b)

11. (b)

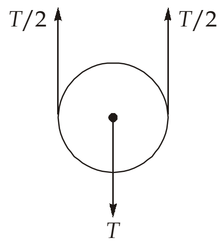
Cylinder



From Newton's first law,

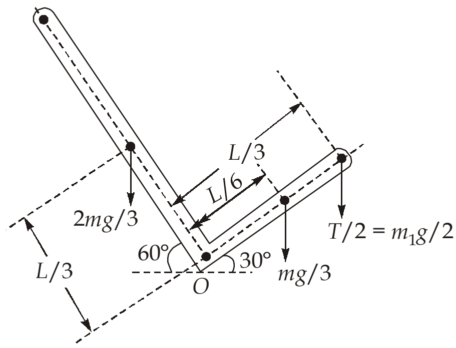
$$m_1g - T = 0$$
$$T = m_1g$$

Pulley



$$\frac{T}{2} = \frac{m_1g}{2}$$

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



$\Sigma M_o = 0$

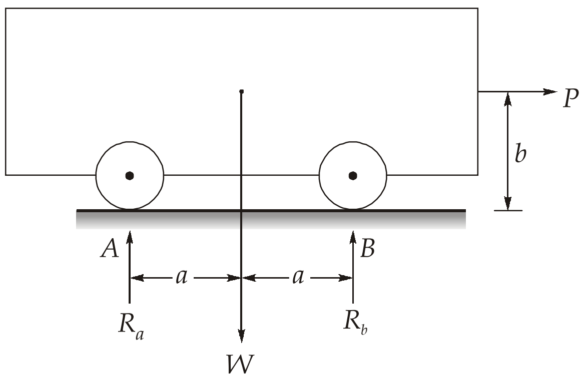
$$\frac{2mg}{3}\times\frac{L}{3}\cos 60° - \frac{mg}{3}\times\frac{L}{6}\cos 30° - \frac{T}{2}\times\frac{L}{3}\cos 30° = 0$$

$$\Rightarrow \quad \frac{2mg}{9}L\cos 60° = \frac{m}{18}gL\cos 30° + \frac{m_1g}{2}\times\frac{L}{3}\cos 30°$$

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

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

12. **(d)**



$$\Sigma F_V = 0$$

$$\Rightarrow \quad R_a + R_b = W$$

Taking moments about B,

$$\Sigma M_B = 0$$

$$\Rightarrow \quad R_a \times 2a + P \times b = W \times a$$

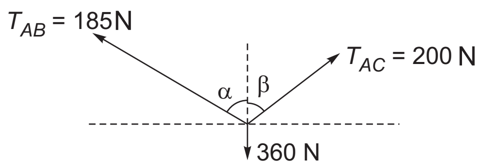
$$\Rightarrow \quad R_a = \frac{Wa - Pb}{2a}$$

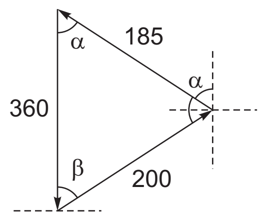
$$\therefore \quad R_b = W - R_a$$

$$\Rightarrow \quad R_b = W - \left(\frac{Wa - Pb}{2a}\right)$$

$$\Rightarrow \quad R_b = \frac{Wa + Pb}{2a}$$

13. (a)





Applying cosine rule

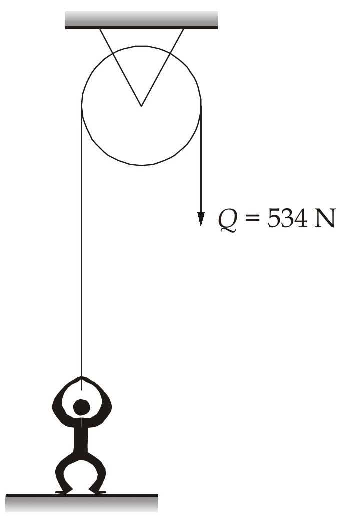
$$185^2 = 360^2 + 200^2 - 2 \times 360 \times 200 \cos\beta$$

$$\beta = 19.93°$$

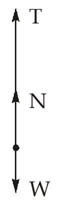
$$200^2 = 360^2 + 185^2 - 2 \times 360 \times 185 \cos\alpha$$

$$\alpha = 21.62°$$

14. (c)



FBD of man

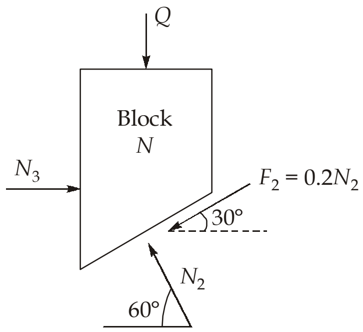


$$T + N = \text{Weight of man} \rightarrow \text{NFL}$$
$$534 + N = 712$$
$$N = 712 - 534$$
$$N = 178 \text{ N}$$

15. (d)

From Newton's first law,

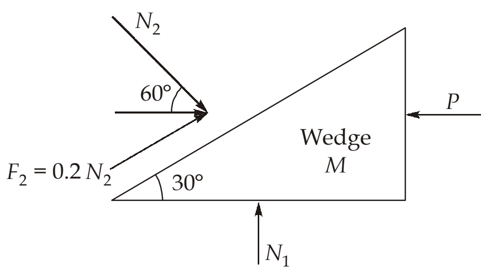
$\Sigma F_y = 0$ for block N



$$N_2 \sin 60° - 0.2N_2 \sin 30° - Q = 0$$
$$Q = 0.766\, N_2$$

$\Sigma F_x = 0$ for wedge M

$$N_2 \cos 60° + 0.2N_2 \cos 30° - P = 0$$
$$P = 0.673\, N_2$$
$$\frac{P}{Q} = \frac{0.673}{0.766}$$
$$P = 0.878Q \simeq 0.9Q$$
$$\alpha = 0.9$$



16. (c)

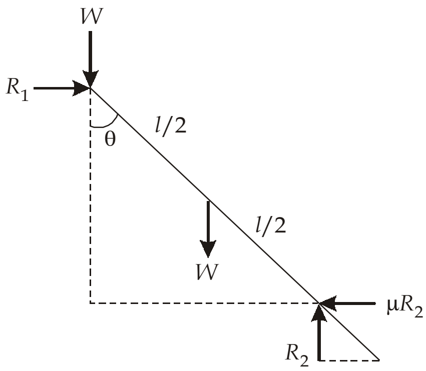
$$\Sigma H = 25 - 20 = 5 \text{ kN } (\rightarrow)$$
$$\Sigma V = 50 + 35 = 85 \text{ kN } (\downarrow)$$

$\therefore$ Resultant force $= \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

$$= \sqrt{5^2 + 85^2}$$
$$= 85.147 \text{ kN}$$

17. (c)

When man is on the top of the ladder, the free body diagram of ladder is



$$R_2 = W + W = 2W$$
$$R_1 = \mu R_2 = \mu W \times 2 = 0.25 \times 2W = 0.5W$$

For moment equilibrium

$$R_1 l \cos\theta = Wl \sin\theta + 0.5\, Wl \sin\theta$$

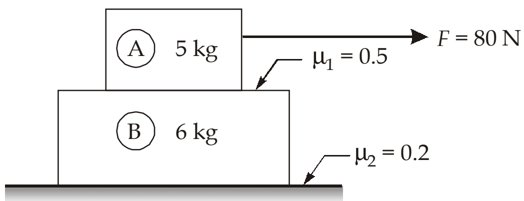
$$\Rightarrow \quad \tan\theta = \frac{R_1}{1.5W} = \frac{0.5W}{1.5W}$$

$$\Rightarrow \quad \theta = \tan^{-1}\left(\frac{1}{3}\right)$$

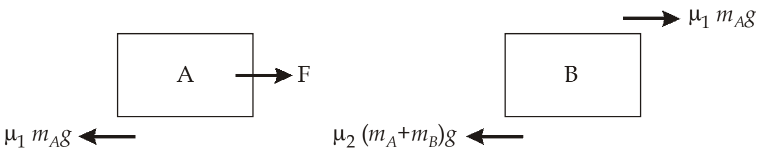
So, $$x = \left(\frac{1}{3}\right)$$

18. (a)

According to question:



FBD of (A) and (B)



Equation of motion for A,

$$F - \mu_1 m_A g = m_A a_A$$
$$80 - 0.5(5)(9.81) = (5)a_A$$
$$a_A = 11.095 \text{ m/s}^2$$

So, $$V_A = U_A + a_A t = 0 + 11.095\,(0.1)$$
$$= 1.1095 \text{ m/s}$$

Now, equation of motion for B,

$$\mu_1 m_A g - \mu_2 (m_A + m_B) g = m_B a_B$$

$$0.5(5)(9.81) - 0.2(5 + 6)9.81 = 6(a_B)$$

$$a_B = 0.4905 \text{ m/s}^2$$

So, $$V_B = U_B + a_B t$$

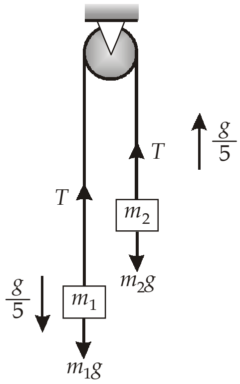
$$= 0 + 0.4905(0.1) = 0.04905 \text{ m/s}$$

∴ Relative velocity of A with respect to B = $V_A - V_B$

$$= 1.1095 - 0.04905$$

$$= 1.06045 \text{ m/s}$$

19. (b)



$$m_1 g - T = m_1 a = \frac{m_1 g}{5} \quad \text{...(i)}$$

$$T - m_2 g = m_2 a = m_2 \frac{g}{5} \quad \text{...(ii)}$$

From (i) and (ii), we get

$$\frac{m_1}{m_2} = \frac{6}{4} = 1.5$$

20. (d)

$$\text{Radial acceleration, } a_r = \frac{V^2}{R} = \frac{(40)^2}{1000} = 1.6 \text{ m/s}^2$$

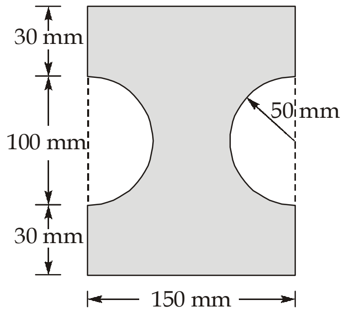
$$\text{Total acceleration, } a = 2 \text{ m/s}^2$$

∴ Maximum deceleration with speed can be decreased is

$$\text{Tangential acceleration, } a_t = \sqrt{a^2 - a_r^2} = \sqrt{(2)^2 - (1.6)^2}$$

$$= \sqrt{4 - 2.56} = \sqrt{1.44} = 1.2 \text{ m/s}^2$$

21. (a)



As the section is symmetrical about its horizontal and vertical axis, therefore centre of gravity of section will lie at the centre of rectangle.

Moment of inertia of the rectangular section about the vertical axis passing through its centre of gravity,

$$I_{G_1} = \frac{db^3}{12} = \frac{160 \times (150)^3}{12} = 45 \times 10^6 \text{ mm}^4$$

Area of one semicircular section,

$$a = \frac{\pi r^2}{2} = \frac{\pi \times 50^2}{2} = 3927 \text{ mm}^2$$

Moment of inertia of a semicircular section about a vertical axis passing through its centre of gravity,

$$I_{G2} = 2 \times 0.11\, r^4 = 2 \times 0.11\, (50)^4 = 2 \times 687.5 \times 10^3 \text{ mm}^4$$

The distance between centre of gravity of semicircular section and its base

$$= \frac{4r}{3\pi} = \frac{4 \times 50}{3\pi} = 21.2 \text{ mm}$$

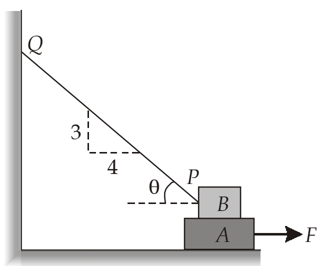
Therefore, moment of inertia of the whole section about a vertical axis passing through the centroid of the section

$$= I_{G_1} - \left[I_{G_2} + ah^2\right]$$

$$= 45 \times 10^6 - \left[2 \times 687.5 \times 10^3 + 2 \times 3927 \times (75 - 21.2)^2\right]$$

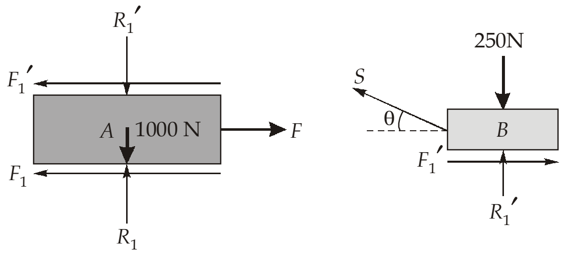
$$= 20.89 \times 10^6 \text{ mm}^4$$

22. (c)



$$\tan\theta = \frac{3}{4}$$

The free body diagrams of the blocks are shown below.



$$F_1 = \mu R_1 \text{ and } F_1' = \mu R_1' \quad \text{...(i)}$$

From equilibrium of block *A*,

$$F - F_1 - F_1' = 0 \quad \text{...(ii)}$$

and $$R_1 - W_1 - R_1' = 0 \quad \text{...(iii)}$$

But $$R_1 = \frac{F_1}{\mu} = W_1 + \frac{F_1'}{\mu} \quad \text{...(iv)}$$

From the equilibrium of block *B*,

$$F_1' - S\cos\theta = 0 \quad \text{...(v)}$$

and $$R_1' + S\sin\theta - W_2 = 0 \quad \text{...(vi)}$$

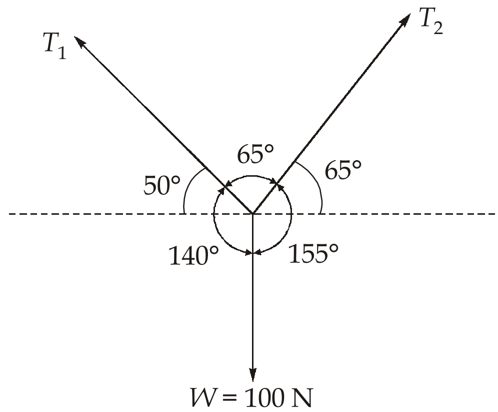
$\Rightarrow$ $$F_1' = \frac{W_2}{1/\mu + \tan\theta} \quad \text{...(vii)}$$

From equations (ii), (iv) and (vii), we get

$$F = \mu W_1 + \frac{2W_2}{\frac{1}{\mu} + \tan\theta} = 0.3 \times 1000 + \frac{2 \times 250}{\frac{1}{0.3} + \frac{3}{4}} = 422.45\,\text{N}$$

23. (b)

Free body diagram



Weight of the light fixture, $W = 100$ N

Lettension in the cable $AB = T_1$

andtension in the cable $BC = T_2$

Apply Lami's theorem $$\frac{T_1}{\sin 155°} = \frac{T_2}{\sin 140°} = \frac{W}{\sin 65°}$$

$\therefore$ $$\frac{T_1}{\sin 155°} = \frac{W}{\sin 65°} = \frac{100}{\sin 65°}$$

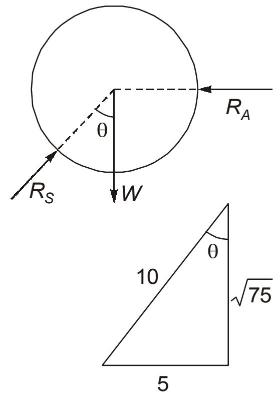
$\Rightarrow$ $$T_1 = 46.63 \text{ N}$$

Similarly, $$\frac{T_2}{\sin 140°} = \frac{W}{\sin 65°} = \frac{100}{\sin 65°}$$

$\Rightarrow$ $$T_2 = \frac{100 \times \sin 140°}{\sin 65°} = 70.92 \text{ N}$$

24. (b)

FBD



$$\Sigma F_y = 0$$

$$W = R_S \cos\theta$$

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

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

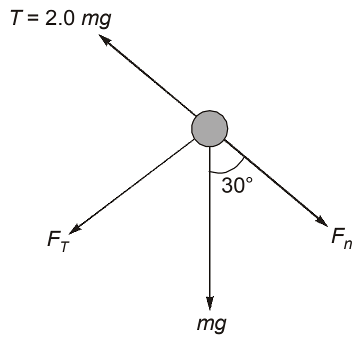
$$\sin\theta = \frac{5}{10}$$

$$\Sigma F_X = 0$$

$$R_S \sin\theta = R_A$$

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

25. (d)



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

$$\text{Normal force, } F_n = T - mg\cos 30°$$

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

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

$$\text{Normal acceleration, } a_n = \frac{F_n}{m}$$

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

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

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

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

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

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