CLASS TEST

S.No.: 01_SK_CE_O_20072025

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ENGINEERING MECHANICS

CIVIL ENGINEERING

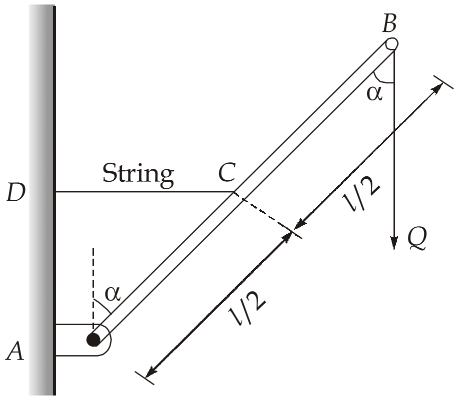
Date of Test : 20/07/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)



Given tension developed in the string = S

Taking moments about A

$$\Sigma M_A = 0$$

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

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

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

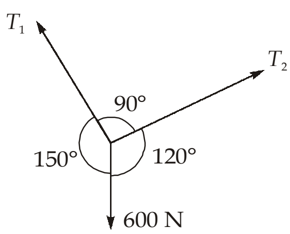
2. (a)

$$\tan\theta = \frac{3}{3} = 1 \Rightarrow \theta = 45^\circ$$

$$F_{CB}\sin 45^\circ = 40$$

$$\therefore \quad F_{CB} = 40\sqrt{2}\ \text{kN}$$

3. (a)



By Lami's Theorem,

$$\frac{T_1}{\sin 120^\circ} = \frac{T_2}{\sin 150^\circ} = \frac{600}{\sin 90^\circ}$$

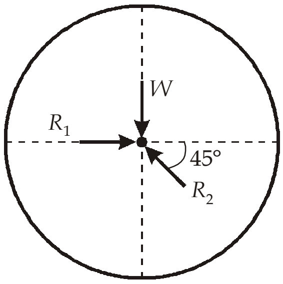
$$\therefore \quad T_1 = 600\sin 120^\circ$$

$$= 519.31 \simeq 520\ \text{N}$$

and $T_2 = 600 \sin 150°$

$T_2 = 300$ N

4. (b)



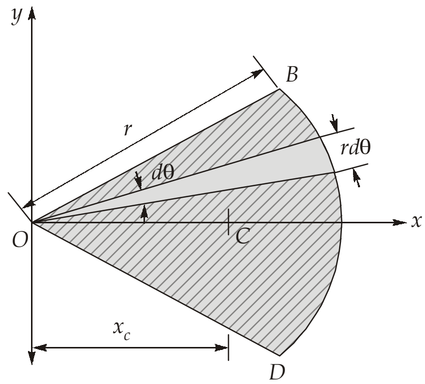
$$R_2 \cos 45° = R_1$$
$$R_2 \sin 45° = W$$
$$R_2 = W \times \sqrt{2}$$
$$R_1 = W \times \sqrt{2} \times \frac{1}{\sqrt{2}} = W$$
$$R_1 = 50 \text{ N} \qquad [\because W = 50 \text{ N}]$$

5. (c)

Considering inifinitesimal triangular element of altitude r and base $rd\theta$. For the given circular sector OBD, there is symmetry about x-axis.

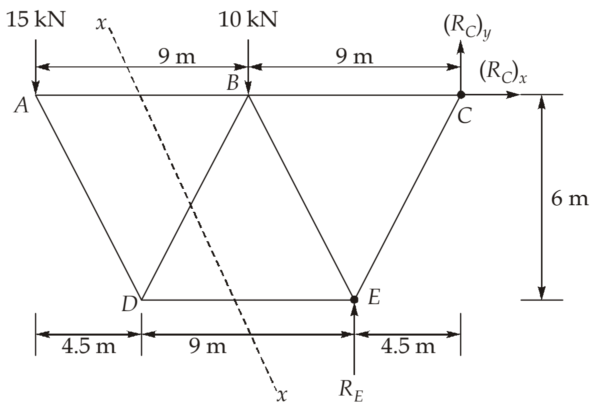
$$x_c = \frac{\int x dA}{\int dA} = \frac{2\int_0^{\alpha/2} \left(\frac{2}{3} r \cos\theta\right) \frac{r^2 d\theta}{2}}{2\int_0^{\alpha/2} \left(\frac{r^2}{2}\right) d\theta}$$

$$= \frac{\left(\frac{r^3}{3}\right) \sin\left(\frac{\alpha}{2}\right)}{\left(\frac{r^2}{2}\right) \times \left(\frac{\alpha}{2}\right)} = \frac{4r}{3\alpha} \sin\frac{\alpha}{2}$$

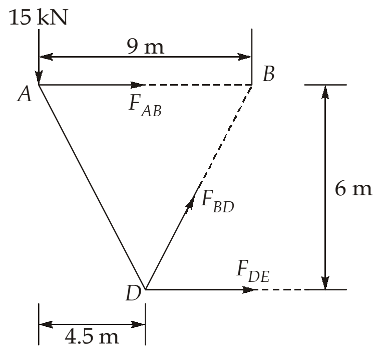


6. (a)

Let the force in member DE is F_{DE}. By method of section.



Taking moment about point B,



$$15 \times 9 + F_{DE} \times 6 = 0$$
$$F_{DE} \times 6 = -135$$
$$F_{DE} = -22.5 \text{ kN}$$
$$F_{DE} = 22.5 \text{ kN (compressive)}$$

7. (c)

Given: Load, W = 500 N, μ_d = 0.5, V = 12.5 m/s

∵ There is no acceleration in the direction normal to the incline.

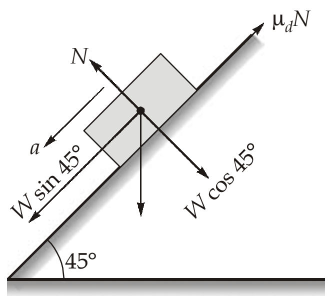
$$N = 500 \cos45° = 353.55 \text{ N}$$

By Newton's law along the incline,

$$500 \sin45° - \mu_d N = \left(\frac{500}{g}\right)a$$

$$353.55 - 0.5 \times 353.55 = \left(\frac{500}{9.81}\right)a$$

$$a = \frac{176.775 \times 9.81}{500} = 3.468 \text{ m/s}^2$$



We know that, if the acceleration is constant on any body/block,
By Newton's laws of motion,

$$V = u + at$$
$$12.5 = 0 + (3.468)t$$
$$t = 3.6044 \text{ second}$$

8. (c)

$$\text{Resultant force, } R = 0.8P$$
$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$
$$(0.8P)^2 = P^2 + P^2 + 2P(P) \times \cos\theta$$
$$-1.36P^2 = 2P^2 \cos\theta$$
$$\theta = \left(132.844° \times \frac{\pi}{180°}\right) = 2.318 \text{ radian}$$

9. (a)

Let s = distance

Average velocity of pet, $V_p = \frac{s}{45}$

Velocity of conveyor, $V_C = \frac{s}{30}$

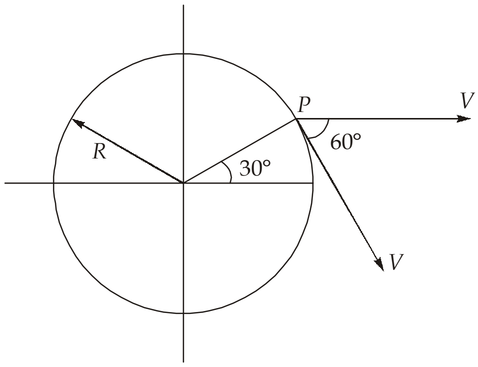
Combined velocity, $V_{P,C} = \frac{s}{30} + \frac{s}{45} = \frac{s}{18}$

$$t = \frac{s}{s/18} = 18 \text{ seconds}$$

10. (d)

The velocity of point Q is zero, as the point Q is in contact with surface.

11. (a)



Magnitude of velocity at point P

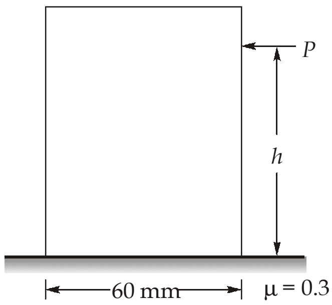
$$= \sqrt{V^2 + V^2 + 2V^2 \cos 60} = \sqrt{2V^2 + 2V^2 \cos 60}$$

$$= V\sqrt{2 + 2\cos 60} = V\sqrt{3}$$

12. (d)

For no tipping or prevent overturning,

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



where, W – weight of block

b – width of block

$$h < Wb/2P \quad ...(1)$$

For slipping without tipping

$$P > f \quad \text{(force of friction)}$$

$$P > \mu W \quad ...(2)$$

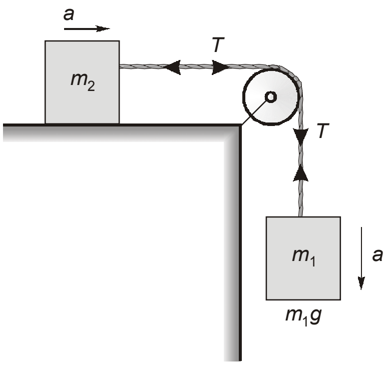
From equation (1) and (2),

$$h < \frac{b}{2\mu}$$

$$h < \frac{60}{0.6}$$

$$h < 100 \text{ mm}$$

13. (c)



$$m_1g - T = m_1a$$

and $$T = m_2a$$

$\Rightarrow$ $$a = \frac{m_1g}{m_1 + m_2}$$

14. (c)

$$v_x = \frac{dx}{dt} = \frac{3}{2}t^2 - 4t$$

$$v_{x(\text{at } t = 1)} = \frac{3}{2} - 4 = -2.5 \text{ m/s}$$

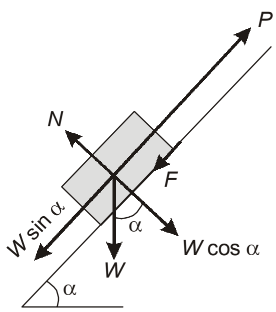
$$v_y = \frac{dy}{dt} = t - 2$$

$$v_{y(\text{at } t = 1)} = 1 - 2 = -1 \text{ m/s}$$

$\therefore$ Velocity of particle, $v = \sqrt{v_x^2 + v_y^2}$

$$= \sqrt{(-2.5)^2 + (-1)^2} = 2.69 \text{ m/s}$$

15. (a)



Let the block is displaced by an amount of Δ.
The equation of virtual work becomes,

$$P \times \Delta - W \sin\alpha \times \Delta - F \times \Delta = 0$$

Here, F = Frictional force = $\mu N = \mu W \cos\alpha$

$$P\Delta - W\Delta \sin\alpha - \mu W \cos\alpha \times \Delta = 0$$

$$\Rightarrow \quad P = W(\mu \cos\alpha + \sin\alpha)$$

Alternatively,

Body will be in equilibrium just before the impending motion. Consider forces along the plane.

$$W \sin\alpha + \text{Friction} = \text{Tension in Rope}$$

$$\Rightarrow \quad W \sin\alpha + \mu \cdot W \cos\alpha = P$$

$$\Rightarrow \quad P = W(\mu \cos\alpha + \sin\alpha)$$

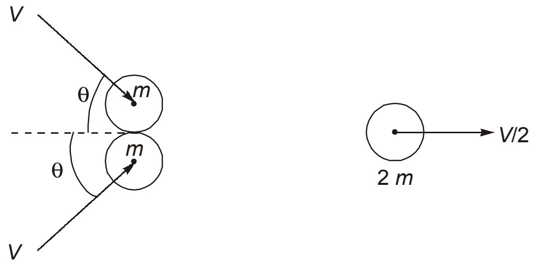
16. (c)

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

$$= \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2 + \frac{1}{2}mV^2$$

$$\text{K.E.} = \frac{1}{5}m\omega^2r^2 + \frac{1}{2}mV^2 = \frac{7}{10}mV^2$$

17. (b)



Momentum will be conserved in x-direction,
Let θ be the angle of velocity of each mass from x-direction as shown in figure.

$$mV\cos\theta + mV\cos\theta = 2m \times \frac{V}{2}$$

$$2\cos\theta = 1$$

$$\cos\theta = \frac{1}{2}$$

$$\theta = 60°$$

So the total angle $= 2\theta = 120°$

18. (a)

Resolving forces in horizontal and vertical direction,

$$\Sigma F_H = 1000\cos 90° + 1500\cos 60° + 1000 \cos 45° + 500\cos 30°$$

$$= 0 + 1500 \times 0.5 + 1000 \times \frac{1}{\sqrt{2}} + 500 \times \frac{\sqrt{3}}{2}$$

$$\Sigma F_H = 750 + 500\sqrt{2} + 250\sqrt{3}$$

$$\Sigma F_H = 1890.12 \text{ N}$$

$$\Sigma F_V = 1000\sin 90° + 1500\sin 60° + 1000 \sin 45° + 500 \sin 30°$$

$$= 1000 + 1500 \times \frac{\sqrt{3}}{2} + 1000 \times \frac{1}{\sqrt{2}} + 500 \times 0.5$$

$$= 1250 + 750\sqrt{3} + 500\sqrt{2}$$

$$\Sigma F_V = 3256.14 \text{ N}$$

$$\text{Resultant force, } R = \sqrt{(\Sigma F_H)^2 + (\Sigma F_V)^2} = \sqrt{(1890.12)^2 + (3256.14)^2}$$

$$R = 3764.97 \text{ N}$$

Taking moment of vertical component of forces about A. Let resultant force R act at a distance of 'x' m from A.

$$(3256.14)x = (1000\sin 90°)\times 0 + (1500\sin 60°) \times 3 + (1000\sin 45°) \times 6 + (500\sin 30°) \times 9$$

$$(3256.14)x = 10389.755$$

$$x = 3.1908 \simeq 3.19 \text{ m}$$

19. (a)

Acceptation of block is given by,

$$\therefore \quad a = \frac{-\mu W}{m}$$

$$\therefore \quad \frac{v\,dv}{dx} = \frac{-\mu W}{m}$$

$$\therefore \quad v\,dv = \frac{-\mu W}{m} dx$$

On integrating

$$\left[\frac{v^2}{2}\right]_{v_0}^{0} = \frac{-\mu W}{m}[dx]_0^x$$

$$0 - \frac{v_0^2}{2} = \frac{-\mu W}{m} \times x$$

$$\Rightarrow \quad \mu = \frac{m v_0^2}{2mx} = \mu = \frac{v_0^2}{2gx}$$

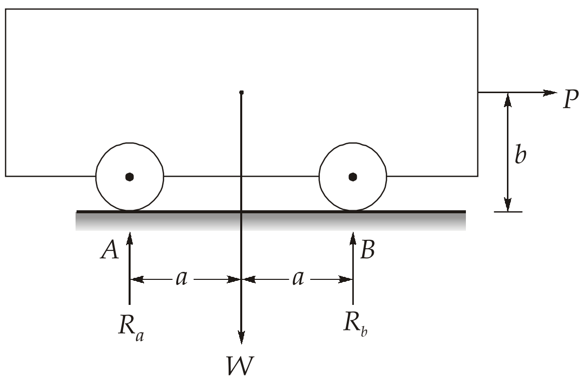
or

$$v^2 = u^2 + 2aS$$

$$0 = v_0^2 + 2(-ug)x$$

$$u = \frac{v_0^2}{2gx}$$

20. (d)



$$\Sigma F_V = 0$$

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

Taking moments about B,

$$\Sigma M_B = 0$$

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

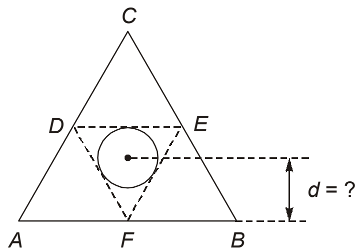
$$\Rightarrow \quad R_a = \frac{Wa - Pb}{2a}$$

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

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

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

21. (a)

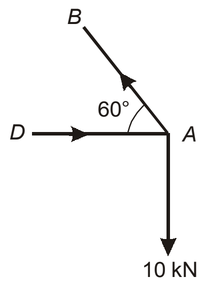


$$AB = BC = CA = a = 5 \text{ m}$$

$$h = \frac{\sqrt{3}}{2}a = \frac{5\sqrt{3}}{2}$$

$$\text{C.G} = \frac{h}{3} = \frac{5\sqrt{3}}{2\times 3} = \frac{5}{2\sqrt{3}} = 1.443 \text{ m}$$

22. (b)



Taking joint A,

Resolving forces, as the trusses in equilibrium,

$$P_{AB} \times \sin 60° = 10$$

$$\Rightarrow \quad P_{AB} = \frac{10}{\sin 60°} = 11.5 \text{ kN (Tensile)}$$

23. (c)

$$\Sigma H = 25 - 20 = 5 \text{ kN } (\rightarrow)$$

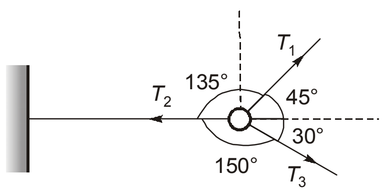
$$\Sigma V = 50 + 35 = 85 \text{ kN } (\downarrow)$$

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

$$= \sqrt{5^2 + 85^2}$$

$$= 85.147 \text{ kN}$$

24. (b)



$\therefore$ Applying lami's theorem as the disc is in equilibrium,

$$\frac{T_1}{\sin 150°} = \frac{T_2}{\sin 75°} = \frac{T_3}{\sin 135°}$$

$$\therefore \quad \frac{T_1}{T_2} = \frac{\sin 150°}{\sin 75°} = 0.517$$

25. (a)

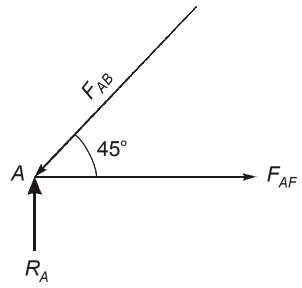
Reaction at A is R_A

Taking moments from point E,

$$W \times \frac{a}{2} + Wa = 2a \cdot R_A$$

$$\therefore \quad R_A = 0.75 \text{ W}$$

Joint A



$$F_{AB} \sin 45° = R_A$$

$$F_{AB} = 1.06\,W \text{ (compressive)}$$

26. (c)

$$I = 2000 \times 0.25^2 = 125 \text{ kg-m}^2$$

$$\text{for retardation, } \omega = \omega_0 + \alpha t$$

$$\omega = 0$$

$$\omega_0 = \frac{2\pi N}{60} = \frac{2\pi \times 3000}{60}$$

$$t = 10 \text{ min} = 600 \text{ sec}$$

$$\alpha = \frac{2\pi \times 3000}{60 \times 600} = 0.5236 \text{ rad/s}$$

So, average frictional torque,

$$I\alpha = 65.44 \text{ Nm}$$

27. (c)

$$\text{Resistance} = \text{mg} + W = 200 \times 9.81 + 100$$

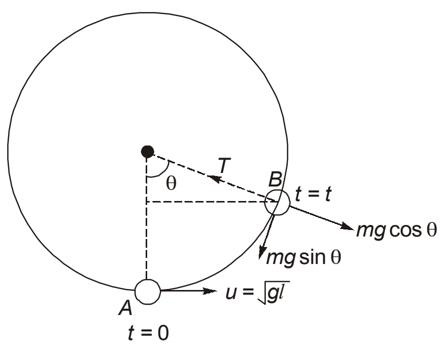
$$= 2062 \text{ N}$$

$$\therefore \quad a = \frac{2062}{200}$$

$$a = 10.31 \text{ m/s}^2$$

$$\frac{V^2}{2a} = S = \frac{4^2}{2 \times 10.31} = 0.776 \text{ m}$$

28. (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,

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

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

$$v = \text{Speed of particle in position on } B$$

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

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

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

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

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),

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

29. (a)

There are three forces acting on the bar AB; pull Q at B, tension in string T = P 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,

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

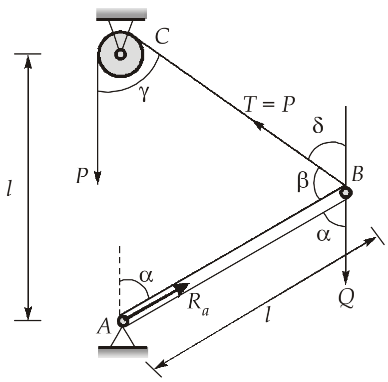
$$Pl\sin(\alpha + \delta) = Ql\sin\alpha$$

$$P\sin(180° - \beta) = Q\sin\alpha$$

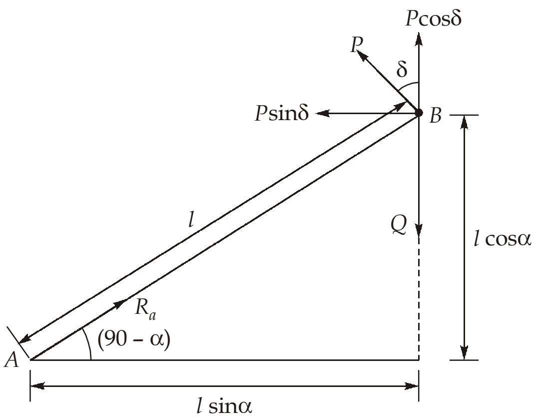
$$P\sin\left[180 - 90 + \frac{\alpha}{2}\right] = Q\sin\alpha$$

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

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



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

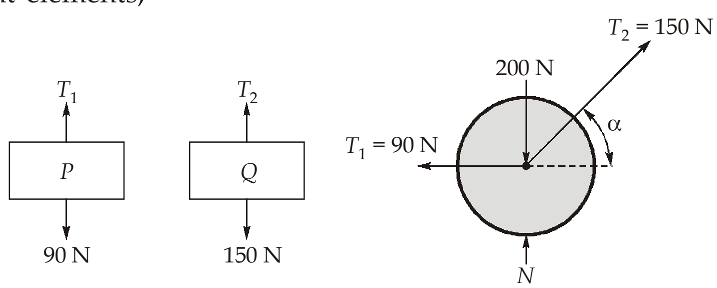


$$\alpha = 2\sin^{-1}\left(\frac{P}{2Q}\right) = 2\sin^{-1}\left(\frac{900}{2\times 2200}\right) = 23.6057°$$

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

30. **(a)**

FBD for different elements,



If there is no friction on pulley,

$$T_1 = 90 \text{ N}, \qquad T_2 = 150 \text{ N}$$

Now, normal reaction between ball and plane,

$$N = 200 - Q\sin\alpha = 200 - 150\sin\alpha$$

By horizontal force balace for ball,

$$T_1 = T_2\cos\alpha$$

$$90 = 150\cos\alpha$$

$$\cos\alpha = 0.6$$

$$\sin\alpha = \sqrt{1-\cos^2\alpha} = \sqrt{1-(0.6)^2} = 0.8$$

Normal reaction between the ball and plane,

$$N = 200 - 150\sin\alpha$$

$$= 200 - 150 \times 0.8$$

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

■■■■