CLASS TEST

S.No.: 01SKME_ABCDEF_10042025

MADE EASY
India's Best Institute for IES, GATE & PSUs
Delhi | Bhopal | Hyderabad | Jaipur | Pune | Kolkata
Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

ENGINEERING MECHANICS

MECHANICAL ENGINEERING

Date of Test : 10/04/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Normal reaction, $N = 500 - P\sin 30° = 500 - 100 \times 0.5 = 450$ N

Limiting Frictional force, $F_{max.} = \mu N = 0.3 \times 450 = 135$ N

But $F = 100\cos 30° = 86.6 \text{ N} \le F_{max}$

So, Friction force $= 86.6$ N

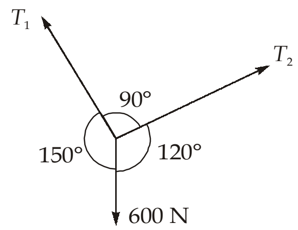
2. (a)

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

$$F_{CB}\sin 45° = 40$$

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

3. (a)



By Lami's Theorem,

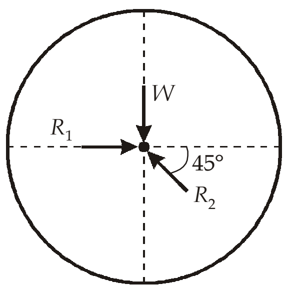
$$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin 150°} = \frac{600}{\sin 90°}$$

$$\therefore \quad T_1 = 600\sin 120° = 519.31 \simeq 520 \text{ N}$$

and $T_2 = 600\sin 150°$

$T_2 = 300$ N

4. (b)



$$R_2\cos 45° = R_1$$

$$R_2\sin 45° = W$$

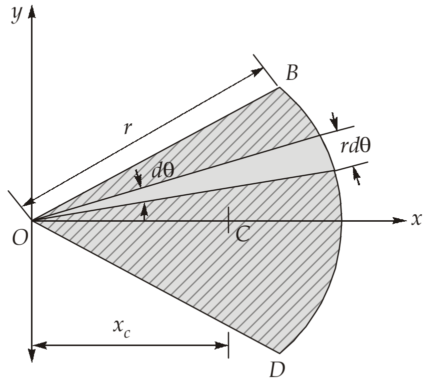
$$R_2 = W \times \sqrt{2}$$

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

$$R_1 = 50 \text{ N} \qquad [\because W = 50 \text{ N}]$$

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.

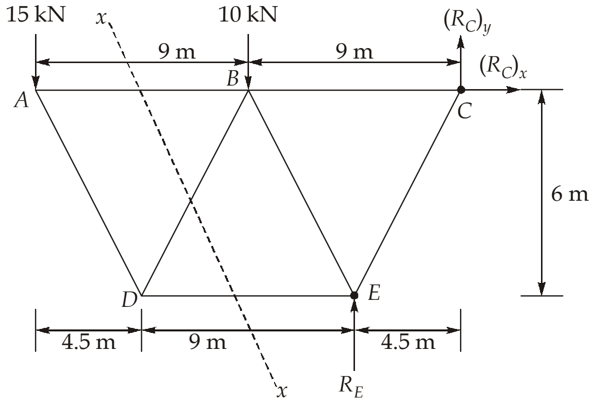


$$x_c = \frac{\int x dA}{\int dA} = \frac{2\int_0^{\alpha/2}\left(\frac{2}{3}r\cos\theta\right)\frac{r^2 d\theta}{2}}{2\int_0^{\alpha/2}\left(\frac{r^2}{2}\right)d\theta}$$

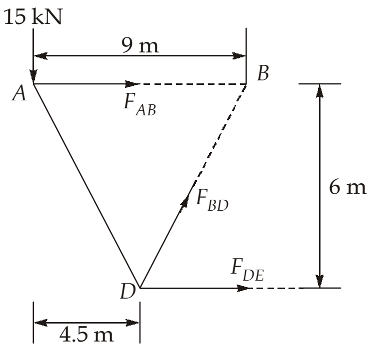
$$= \frac{\left(\frac{r^3}{3}\right)\sin\left(\frac{\alpha}{2}\right)}{\left(\frac{r^2}{2}\right)\times\left(\frac{\alpha}{2}\right)} = \frac{4r}{3\alpha}\sin\frac{\alpha}{2}$$

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, $\mu_d = 0.5$, $V = 12.5$ m/s

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

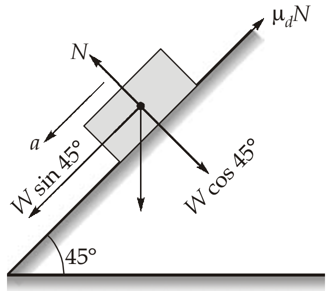
$$N = 500\cos 45° = 353.55 \text{ N}$$

By Newton's law along the incline,

$$500\sin 45° - \mu_d N = \left(\frac{500}{g}\right)a$$

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

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



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, $V_C = \frac{s}{30}$

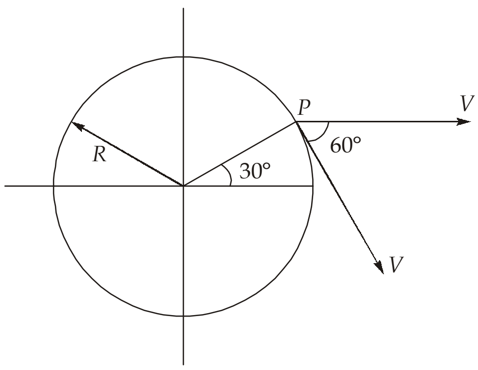
Combined velocity, $V_{P,C} = \frac{s}{30} + \frac{s}{45} = \frac{s}{18}$

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

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

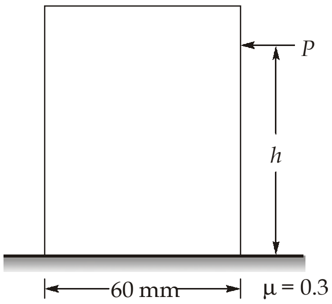
$$= \sqrt{V^2 + V^2 + 2V^2 \cos 60} = \sqrt{2V^2 + 2V^2 \cos 60}$$

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

12. (d)

For no tipping or prevent overturning,

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



where, W – weight of block

b – width of block

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

For slipping without tipping

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

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

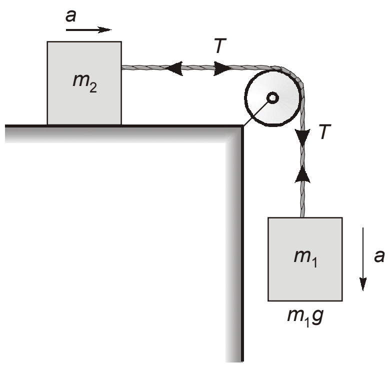
From equation (1) and (2),

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

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

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

13. (c)



$$m_1 g - T = m_1 a$$

and

$$T = m_2 a$$

$\Rightarrow$

$$a = \frac{m_1 g}{m_1 + m_2}$$

14. (c)

As the body just reaches the top most point B, therefore

$$v_A = \sqrt{5gL} \text{ and } v_B = \sqrt{gL}$$

Let the point be C having angular displacement θ at which speed becomes half of the initial value v_A.

Using the law of conservation of energy,

$$\text{Energy at } A = \text{Energy at } C$$

$$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_c^2 + mgL(1-\cos\theta)$$

$$\frac{1}{2}m\left(v_A^2 - v_C^2\right) = mgL(1-\cos\theta)$$

$$\frac{1}{2}m\left(5gL - \frac{5gL}{4}\right) = mgL(1-\cos\theta)$$

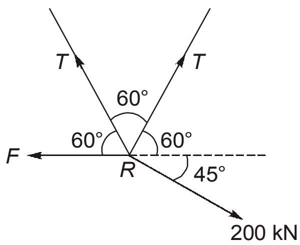
$$\frac{15}{8} = 1-\cos\theta$$

$$\cos\theta = \frac{-7}{8}$$

So θ lies between $\frac{3\pi}{4}$ and π

or, $$\frac{3\pi}{4} < \theta < \pi$$

15. (c)



Since PR and QR are identically loaded, so considering horizontal equilibrium,

$$T\cos 60 + F = T\cos 60° + 200\cos 45°$$

$$F = 200\cos 45° = 200 \times \frac{1}{\sqrt{2}} = 141.4 \text{ kN}$$

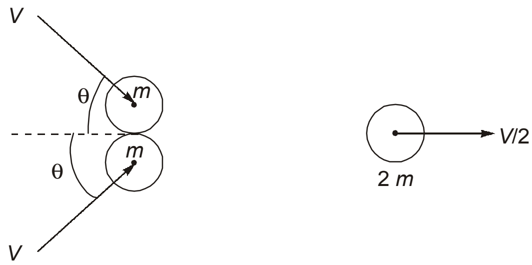
16. (c)

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

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

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

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,

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

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

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

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

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

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

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

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

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)

Acceleration 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. (b)

$$\text{Force} = f_0 - kt$$

Let m be the mass of the particle,

$$\therefore \quad \frac{md^2x}{dt^2} = f_0 - kt$$

On integrating,

$$\frac{dx}{dt} = \frac{1}{m}\left[f_0 \times t - \frac{kt^2}{2} + C\right]$$

At $t = 0$,

$V = 0$

$$\Rightarrow \quad \frac{dx}{dt} = 0$$

$$\therefore \quad C = 0$$

$$\therefore \quad \frac{dx}{dt} = \frac{1}{m}\left[f_0 t - \frac{kt^2}{2}\right]$$

$$x = \frac{1}{m}\left[\frac{f_0 t^2}{2} - \frac{k}{2} \times \frac{t^3}{3} + C^1\right]$$

At $t = 0; x = 0$

$\Rightarrow \quad C' = 0$

At $x = 0$

We have,

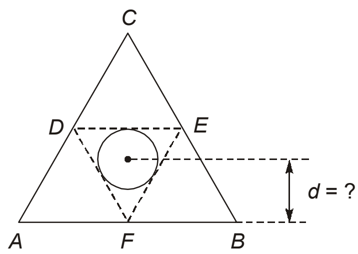
$$\frac{1}{m}\left[\frac{f_0 t^2}{2} - \frac{kt^3}{6}\right] = 0$$

$$\Rightarrow \quad \frac{f_0 t^2}{2} = \frac{kt^3}{6}$$

$$\Rightarrow \quad t = \frac{6f_0}{2k} = \frac{6\times 53.4}{2\times 8.9}$$

$$t = 18 \text{ sec}$$

21. **(a)**

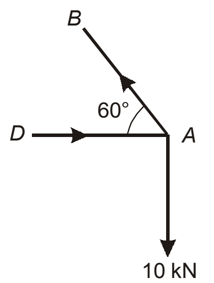


$$AB = BC = CA = a = 5 \text{ m}$$

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

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

22. **(b)**



Taking joint A,

Resolving forces, as the trusses in equilibrium,

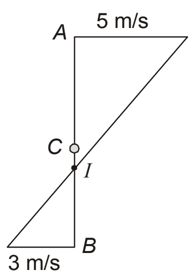
$$P_{AB} \times \sin 60° = 10$$

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

23. **(b)**

∵ Velocities are in opposite directions,

∴ I will lie between A and B,



$$\frac{IA}{IB} = \frac{V_a}{V_b} = \frac{5}{3}$$

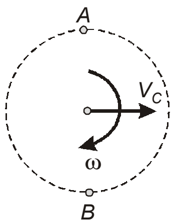
$$\Rightarrow \quad \frac{0.5 - IB}{IB} = \frac{5}{3}$$

$$IB = 0.1875 \text{ m}$$

$$IA = 0.3125 \text{ m}$$

$$\omega = \frac{V_A}{IA} = \frac{5}{0.3125} = 16 \text{ rad/s}$$

Alternatively,



$$\therefore \quad V_A = V_C + R\omega$$

$$V_B = R\omega - V_C$$

$$\therefore \quad V_C + R\omega = 5$$

$$R\omega - V_C = 3$$

$$V_C + 0.25\,\omega = 5 \qquad \text{...(a)}$$

$$0.25\,\omega - V_C = 3 \qquad \text{...(b)}$$

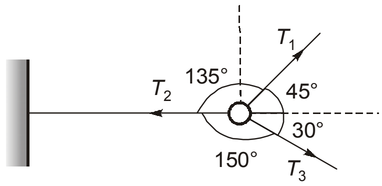
On solving (a) and (b),

$$\omega = 16 \text{ rad/s}$$

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

where V_C = velocity of centre C.

24. (b)



∴ 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)

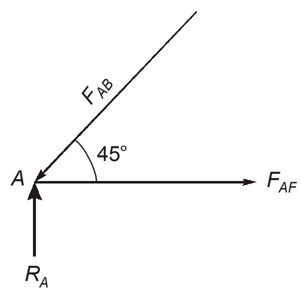
Reaction at A is R_A

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)

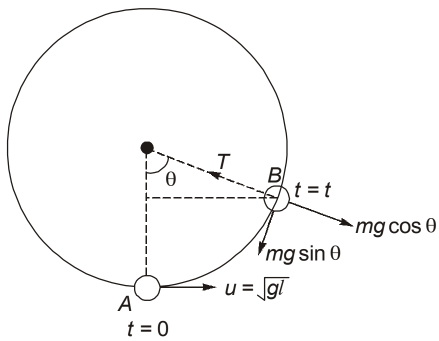
$$\text{Resistance} = \text{mg} + W = 200 \times 9.81 + 100$$
$$= 2062 \text{ N}$$

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

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

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

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 = 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,

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

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

$$P\sin(180° - \beta) = Q\sin\alpha$$

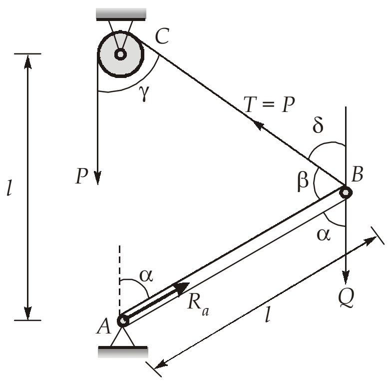
$$P\sin\left[180 - 90 + \frac{\alpha}{2}\right] = Q\sin\alpha$$

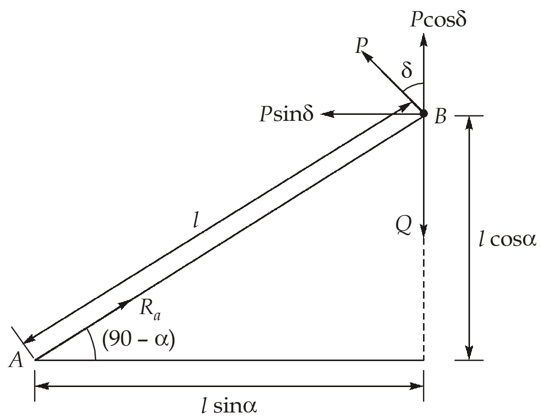
$$P\cos\frac{\alpha}{2} = 2Q\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}$$

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

or

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



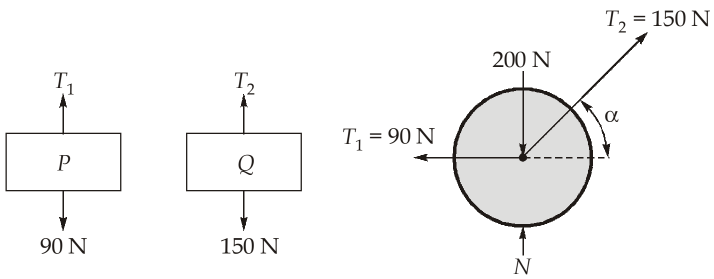


$$\alpha = 2\sin^{-1}\left(\frac{P}{2Q}\right) = 2\sin^{-1}\left(\frac{900}{2\times 2200}\right) = 23.6057°$$

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

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,

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

$$= 200 - 150\times 0.8$$

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

■■■■