CLASS TEST

S.No. : 01 PT_CE_ABC_110722

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ENGINEERING MECHANICS

CIVIL ENGINEERING

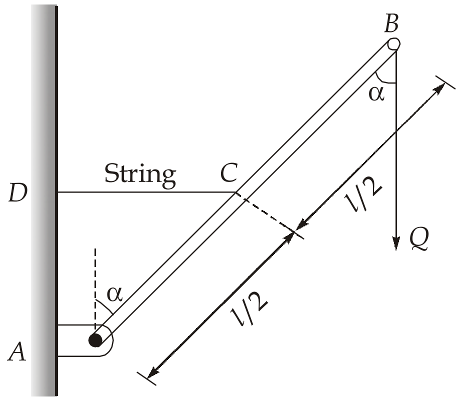
Date of Test : 15/07/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)



Given tension developed in the string = S

Taking moments about A

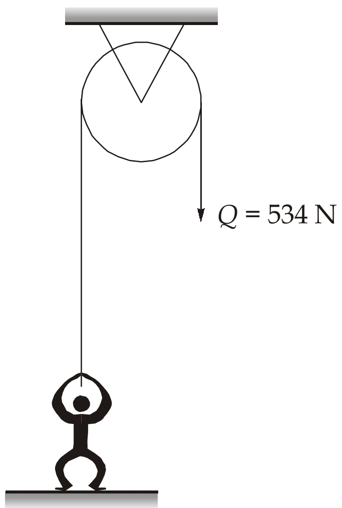
$$\Sigma M_A = 0$$

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

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

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

2. (c)

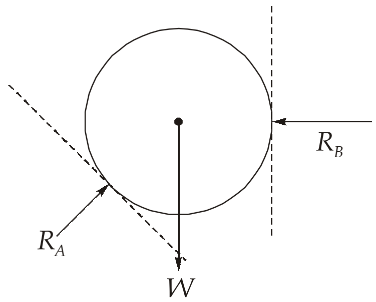


FBD of man

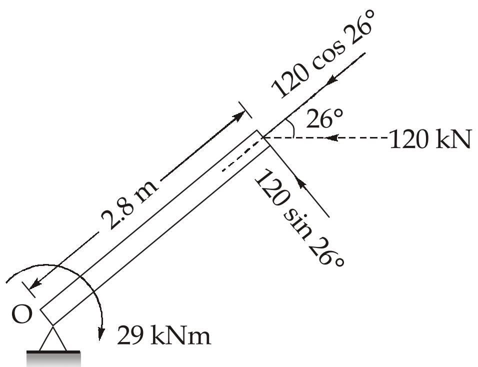
$$T + N = \text{Weight of man} \rightarrow \text{NFL}$$
$$534 + N = 712$$
$$N = 712 - 534$$
$$N = 178 \text{ N}$$

3. **(d)**

FBD of cylinder



4. **(c)**

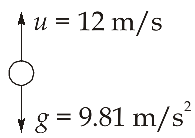


$$M_o = 120 \sin 26° \times 2.8 \text{ (CW)} - 29 \text{ (ACW)}$$
$$= 118.2927 \text{ kNm (CW)}$$

Reactive moment will be opposite of M_o i.e., ACW.

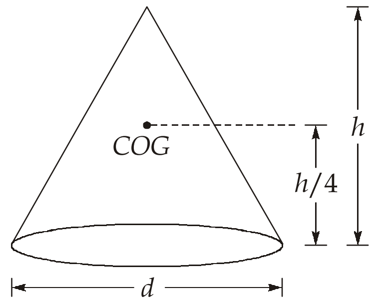
5. **(b)**

6. **(c)**



$$v = u + gt$$
$$\Rightarrow \quad v = (-12) + 9.81 \times 2$$
$$= 7.62 \text{ m/sec}$$

7. **(4)**



8. **(a)**

9. **(b)**

Time period of simple pendulum is given by,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Here, $$T = \frac{53}{24} = 2.208 \text{ sec}$$

Therefore, $$2.208 = 2\pi\sqrt{\frac{1.2}{g}}$$

$\therefore$ $$g = 9.717 \text{ m/s}^2$$

10. **(b)**

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

$$\omega_0 = 0$$

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

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

11. **(a)**

The linear speed at t = 4 sec is

$$V = 3t^2 - 6t$$

$$= 3 \times (4)^2 - 6 \times 4$$

$$= 24 \text{ m/s}$$

The radial acceleration is,

$$a_r = \frac{V^2}{r} = \frac{24^2}{0.55} = 11.52 \text{ m/s}^2$$

12. **(a)**

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$= \sqrt{90^2 + 140^2 + 2 \times 140 \times 90 \times \cos 70} = 190.58 \text{ kN}$$

$$\tan\phi = \frac{Q\sin\theta}{P + Q\cos\theta}$$

$$= \frac{140\sin 70}{90 + 140\cos 70} = 0.954$$

$$\therefore \quad \phi = 43°39'$$

13. (d)

$$\omega_A = \omega_B$$

$$\Rightarrow \quad \frac{V_A}{R - 0.3} = \frac{V_B}{R} \qquad (\because \; V = \omega R)$$

$$\Rightarrow \quad \frac{60}{R - 0.3} = \frac{120}{R}$$

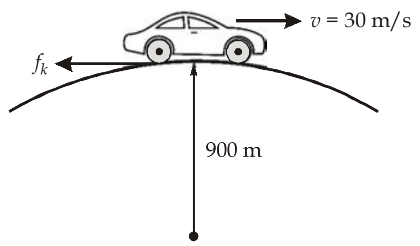
$$\Rightarrow \quad 60\,R = 120\,R - 36$$

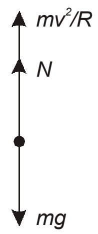
$$\Rightarrow \quad 36 = 60\,R$$

$$\Rightarrow \quad R = \frac{36}{60} = 0.6 \text{ m}$$

$$\therefore \quad D = 2\,R = 1.2 \text{ m} = 1200 \text{ mm}$$

14. (b)





$$a = \frac{f_k}{m} = \frac{\mu_k N}{m} \qquad \text{...(i)}$$

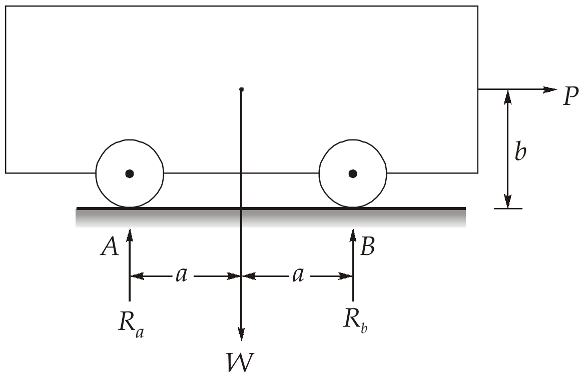
Also, $$N = mg - \frac{mv^2}{R} \qquad \text{...(ii)}$$

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

$$a = \frac{0.7\,m\left[g - \frac{v^2}{R}\right]}{m} \qquad [\because \; \mu = 0.7]$$

$$= 0.7\left[10 - \frac{30^2}{900}\right] = 6.3 \text{ m/s}^2$$

15. **(d)**



$$\Sigma F_V = 0$$

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

Taking moments about B,

$$\Sigma M_B = 0$$

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

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

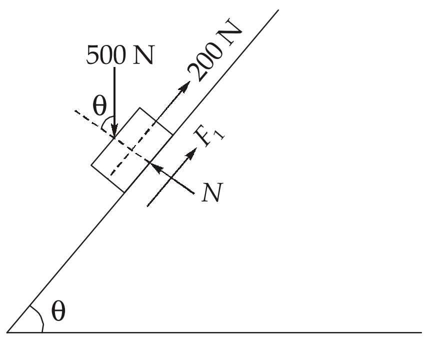
$$\therefore \quad R_b = W - R_a$$

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

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

16. **(c)**

Case (i) : Block just moves downwards



Perpendicular to the inclined plane

$$N = 500\cos\theta$$

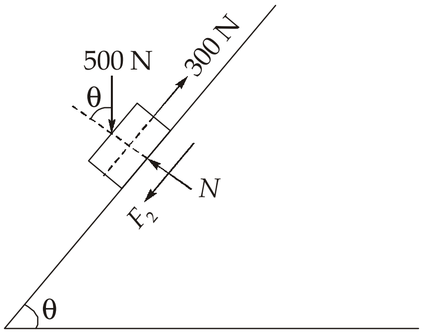
$$F_1 = \mu N = \mu\, 500\cos\theta$$

Parallel to the inclined plane

$$\Rightarrow \quad 200 + F_1 = 500\sin\theta$$

$$\Rightarrow \quad 200 + \mu\, 500\cos\theta = 500\sin\theta \qquad \text{...(i)}$$

Case (ii) : Block just moves upwards



Perpendicular to the inclined plane

$$N = 500\cos\theta$$

$$F_2 = \mu N = \mu\, 500\cos\theta$$

Parallel to the inclined plane

$$\Rightarrow \quad 500\sin\theta + F_2 = 300$$

$$\Rightarrow \quad 500\sin\theta + \mu\, 500\cos\theta = 300 \quad \text{...(ii)}$$

Eq. (ii) – (i),

$$100\sin\theta = 500$$

$$\Rightarrow \quad \sin\theta = 0.5$$

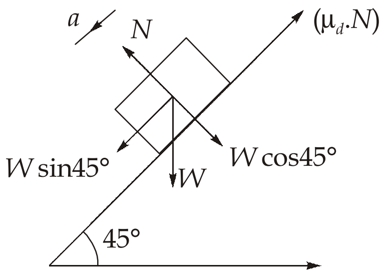
$$\therefore \quad \theta = 30°$$

Substituting the value of θ in eq. (ii)

$$500\sin 30° + \mu\, 500\cos 30° = 300$$

$$\Rightarrow \quad \mu = \frac{50}{500\cos 30°} = 0.11547 \simeq 0.115$$

17. (d)



Since there is no acceleration in the direction normal to the inclined,

$$N = W\cos 45°$$

$$= 500\cos45° = 353.55 \text{ N}$$

By Newton's law along the inclined

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

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

$$a = 3.468 \text{ m/s}^2 \simeq 3.47 \text{ m/s}^2.$$

Acceleration remain constant on the body, so at any time t acceleration will be 3.47 m/s^2.

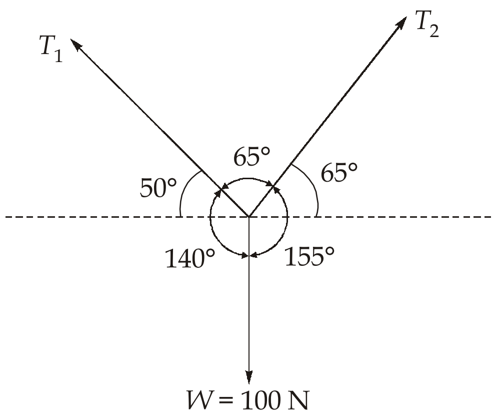
Now, $V = u + at$

$$12.5 = 0 + 3.47 \times t$$

$$t = 3.6 \text{ sec}$$

18. (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 $\dfrac{T_1}{\sin 155°} = \dfrac{T_2}{\sin 140°} = \dfrac{W}{\sin 65°}$

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

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

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

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

19. (c)

Given,initial velocity of train (u) =0 (because it starts from rest)

Acceleration = a

Distance covered in 1st second = S_1

Distance covered in 2nd second = S_2

anddistance covered in 3rd second = S_3

We know that distance covered by the train in 1st second,

$$S_1 = u + \frac{a}{2}(2n_1 - 1) = 0 + \frac{a}{2}[(2\times 1) - 1] = \frac{a}{2} \quad \text{...(i)}$$

Similarly distance covered in 2nd second,

$$S_2 = u + \frac{a}{2}(2n_2 - 1) = 0 + \frac{a}{2}[(2\times 2) - 1] = \frac{3a}{2} \quad \text{...(ii)}$$

and distance covered in 3rd second,

$$S_3 = u + \frac{a}{2}(2n_3 - 1) = 0 + \frac{a}{2}[(2\times 3) - 1] = \frac{5a}{2} \quad \text{..(iii)}$$

$\therefore$ Ratio of distances $S_1 : S_2 : S_3$ $= \frac{a}{2} : \frac{3a}{2} : \frac{5a}{2} = 1:3:5$

20. (d)

$$S = t^3 - 2t^2 + 3$$

$$V = \frac{dS}{dt} = 3t^2 - 4t$$

$$a = \frac{dV}{dt} = \frac{d^2S}{dt^2} = 6t - 4$$

$\therefore$ $a_{t = 5\text{ sec}} = 6 \times 5 - 4$

$= 26 \text{ m/sec}^2$

21. (c)

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

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

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

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

$= 85.147$ kN

22. (d)

For resultant to be in vertical direction,

$\Sigma F_x = 0$

$\Rightarrow$ 180 cos α = 100 cos α + 160 cos (α + 30°)

$\Rightarrow$ 80 cos α = 160 cos (α + 30°)

$\Rightarrow$ cos α = 2 [cos α cos 30° – sin α sin 30°]

$\Rightarrow$ cos α = 1.732 cos α – sin α

$\Rightarrow$ sin α = 0.732 cos α

$\Rightarrow$ tan α = 0.732

$\Rightarrow$ α = 36.204°

Resultant force in vertical direction,

R_y = 180 sin 36.204° + 160 sin (36.204° + 30°) + (100 sin 36.204°)

= 106.32 + 146.39 + 59.066

= 311.783 kN

23. (d)

Given:

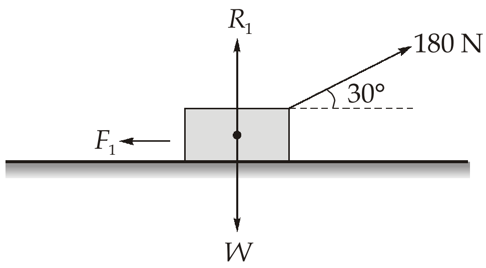
Pull = 180 N; Push = 200 N and angle at which force is inclined with horizontal plane (α) = 30°.

Let, W = Weight of the body

R = Normal reaction

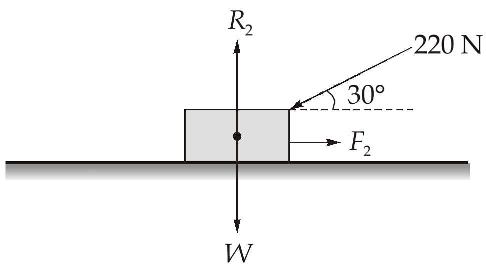
μ = Coefficient of friction

$$R_1 = W - P_1 \sin 30°$$
$$= W - 05 \times 180$$
$$= (W - 90) \text{ N}$$



$$F_1 = P_1 \cos 30°$$

$\Rightarrow$ $$\mu(W - 90) = 180 \times 0.866 = 155.88 \ldots\text{(i)}$$



$$R_2 = W + P_1 \sin 30°$$
$$= (W + 220 \times 0.5)$$
$$= (W + 110) \text{ N}$$
$$F_1 = P_2 \cos 30°$$

$\Rightarrow$ $$\mu(W + 110) = 220 \times 0.866 = 190.52 \ldots\text{(ii)}$$

From eq. (i) and (ii)

$$\frac{W - 90}{W + 110} = \frac{155.88}{190.52} = 0.8182$$

$\Rightarrow$ $$W - 90 = 0.8182 \text{ W} + 90.002$$

$\Rightarrow$ $$W = 990.1 \simeq 990 \text{ N}$$

Substituting W either in eq. (i) or (ii)

$$\mu = 0.1732$$

24. (c)

$$v = u + at(\text{time taken to reach max heights } \frac{5}{2} = 2.5 \text{ sec})$$

At the highest point, $v = 0$

$\therefore$ $u = (=)\ (gt) = gt (\because a = -g)$

$\Rightarrow$ $u = 9.81 \times 2.5$

$= 24.525$ m/sec

Now, $v^2 = u^2 + 2\,ah$

$\Rightarrow$ $0 = u^2 - 2\,gh$

$\Rightarrow$ $24.525^2 = 2 \times 9.81 \times h$

$\Rightarrow$ $h = 30.66$ m

25. (a)

KE of a flywheel revolving about an axis is given by

$$kE = \frac{1}{2} Iw^2$$

$$I_{\text{disc/flyweel}} = \frac{mr^2}{2} = \frac{10 \times (0.5)^2}{2}$$

where $m = 10$ kg, $r = 500$ mm, $= 0.5$ m

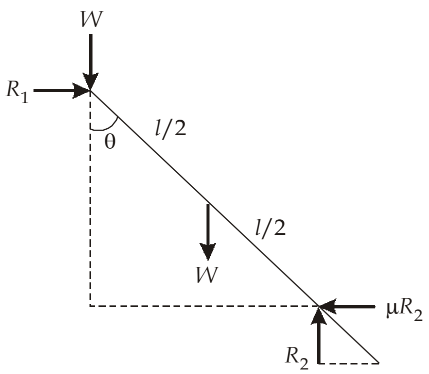
$\therefore$ $I_{\text{disc/flywheel}} = 5 \times 0.25 = 1.25 \text{ kgm}^2$

$$w = \frac{2\pi N}{60} = \frac{2\pi \times 600}{60} = 20\pi = 62.8 \text{ rad/sec}$$

$\therefore$ $$KE = \frac{1}{2} \times 1.25 \times (20\pi)^2 = 2467.4 \text{ Joules}$$

26. (c)

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



$R_2 = W + W$

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

For moment equilibrium

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

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

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

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

27. (d)

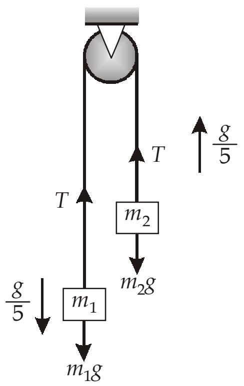
$$\text{Radial acceleration, } a_r = \frac{V^2}{R} = \frac{(40)^2}{1000} = 1.6 \text{ m/s}^2$$

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

∴ Maximum deceleration with speed can be decreased is

$$\text{Tangential acceleration, } a_t = \sqrt{a^2 - a_r^2} = \sqrt{(2)^2 - (1.6)^2}$$
$$= \sqrt{4 - 2.56} = \sqrt{1.44} = 1.2 \text{ m/s}^2$$

28. (b)



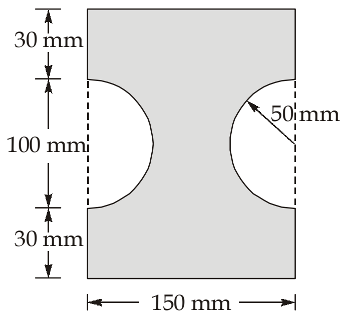
$$m_1 g - T = m_1 a = \frac{m_1 g}{5} \qquad \text{...(i)}$$

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

From (i) and (ii), we get

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

29. (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

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

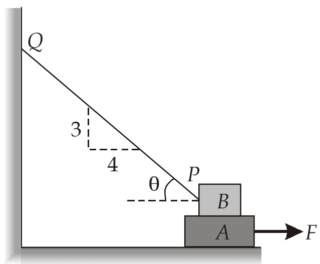
Therefore, moment of inertia of the whole section about a vertical axis passing through the centroid of the section

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

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

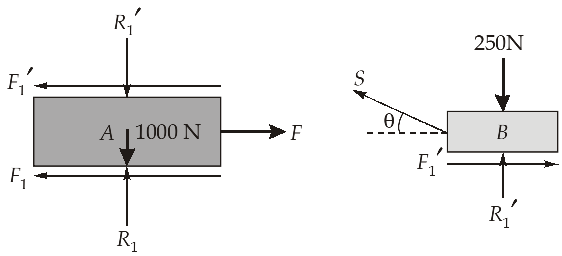
$$= 20.89 \times 10^6 \text{ mm}^4$$

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

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

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

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

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