KSU CET

S1 & S2 Notes

2019 Scheme

Manifest the leadership in you

Reg No.:_______________ Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

First Semester B.Tech Degree Examination December 2021 (2019 scheme)

Course Code: EST100

Course Name: ENGINEERING MECHANICS

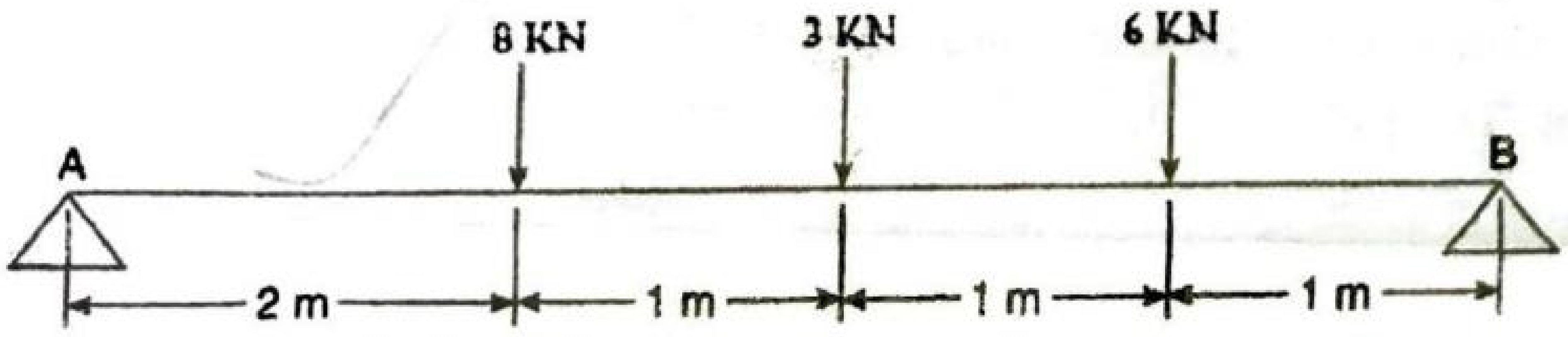
(2019 -Scheme)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks Marks

1	List out and explain systems of forces.	(3)
2	State & Explain the Varignon's theorem 3	(3)
3	Define coefficient of friction. Show that the coefficient of friction is tangent of the angle of friction 3	(3)
4	Find the reactions at A and B	(3)



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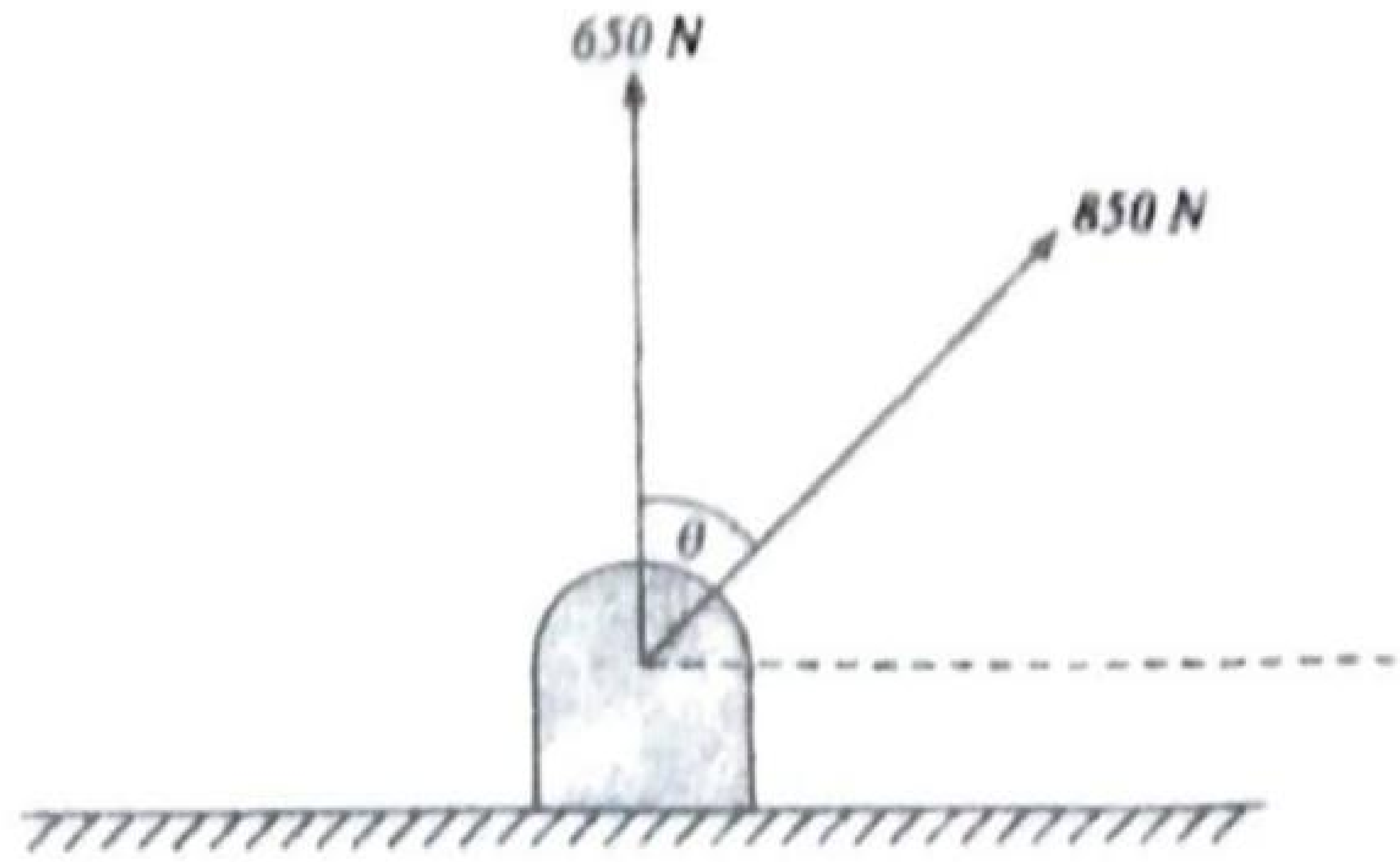
5	Discuss the generation of area by theorem of Pappus Guldinus 3	(3)
6	State and explain parallel axis theorem. 3	(3)
7	Discuss the use of D-Alembert's principle used for the analysis of a moving rigid body 3	(3)
8	A stone is dropped from the top of a tower 70 m high. At the same time another stone is thrown up from the foot of the tower with a velocity of 30 m/s. At what distance from the top and after how much time the two stones cross each other? 3	(3)
9	What do you mean by instantaneous centre of rotation? How can it be located for a body moving with combined motion of rotation and translation?	(3)
10	What do you mean by general plane motion? Give two examples of bodies performing combined motion of rotation and translation 2	(3)

PART B

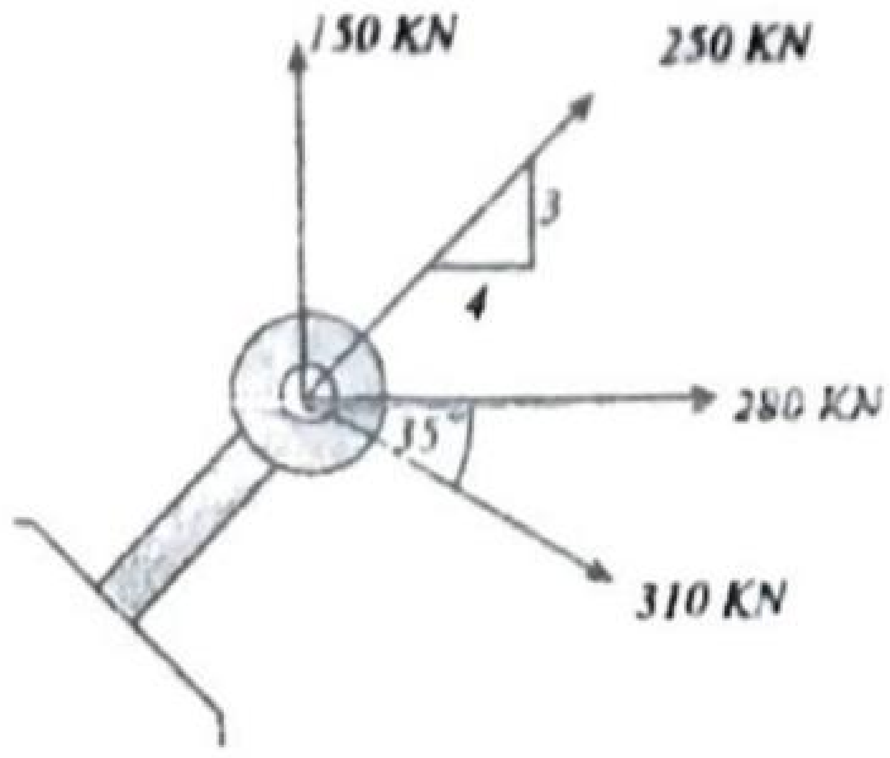
Answer one full question from each module, each question carries 14 marks.

MODULE 1

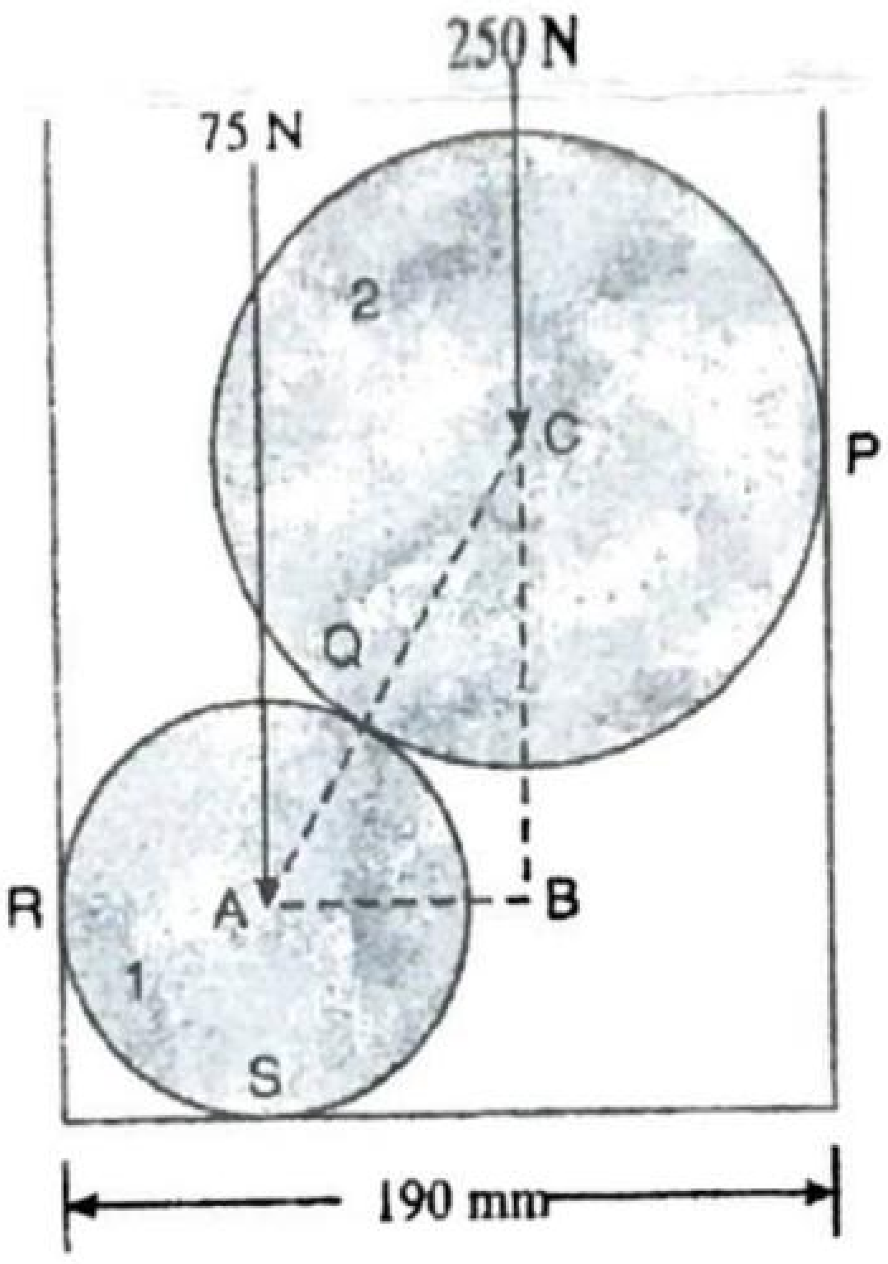
11	a	Determine angle between the forces and the direction of the resultant shown in figure. The resultant of the two forces is 1300 N.	(7)



11 b Four forces are acting on a bolt as shown in Figure 3.10. Determine the magnitude and direction of the resultant force (7)



12 Determine the reactions at contact points P, Q, R, and S for the system shown in Figure. The radii of spheres 1 and 2 are, respectively, 40 mm and 60 mm. (14)



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MODULE 2

13 a A uniform ladder AB of length 4.00 m and weighing 300 N is placed against a smooth wall with its lower end 1.50 m from the wall. The coefficient of friction between the ladder and the floor is 0.25. What is the frictional force acting at the point of contact between the ladder and the floor? Show that the ladder will remain in equilibrium in this position. (7)

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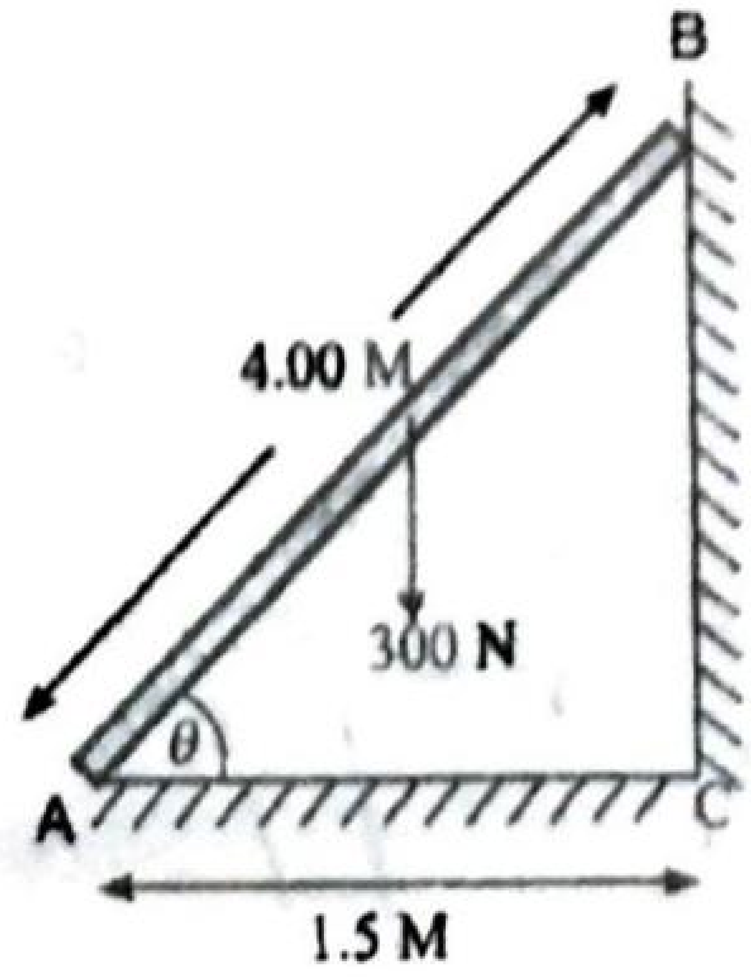
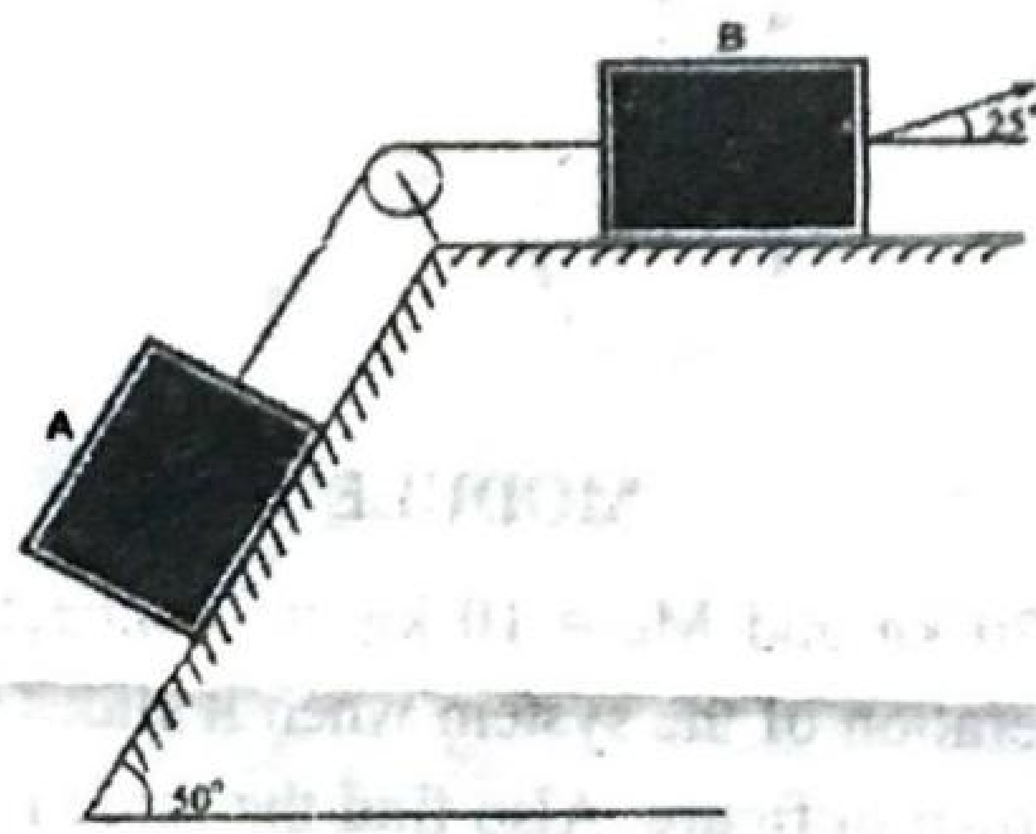


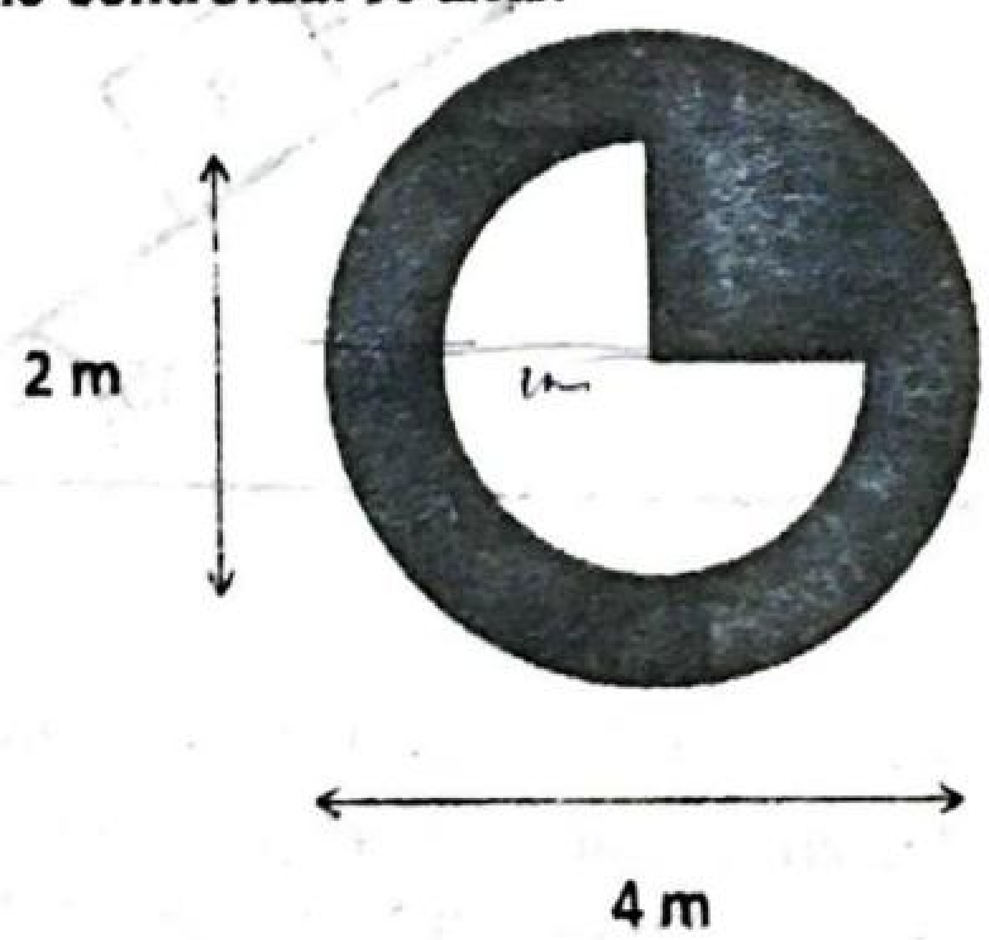
13 b Explain angle of friction and angle of repose. Show that angle of repose is equal to angle of friction. (7) 7

14 Two blocks A and B weighing 6 kN and 3.5 kN, respectively, are connected by a wire passing over a smooth frictionless pulley as shown in Figure. Determine the magnitude of force P which is applied on block B at 25° from horizontal as shown in figure. Take $\mu = 0.20$. (14)

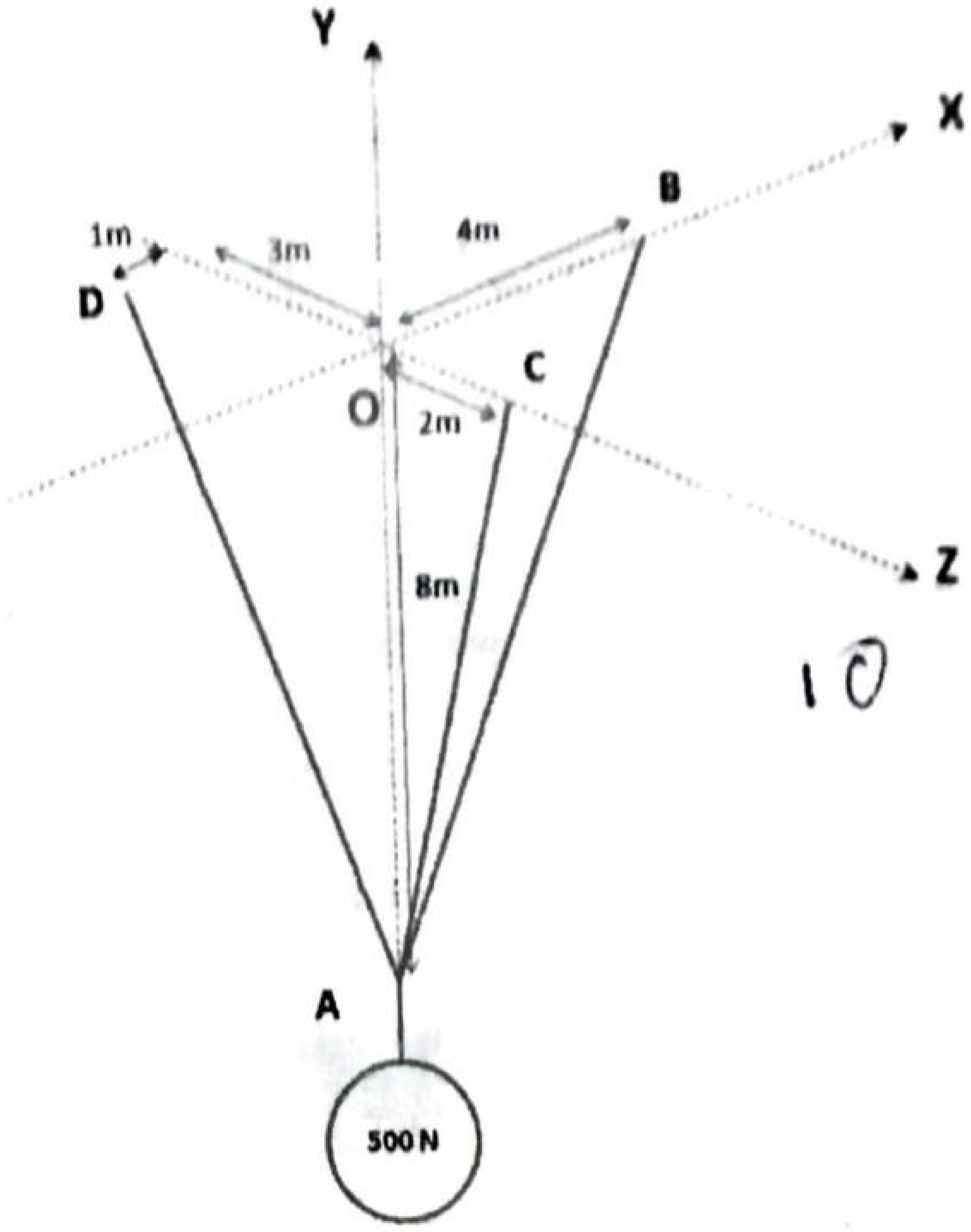


MODULE 3

15 From a circular lamina of diameter 4m, 3/4th quarter circle of diameter 2m has been remove from the centre. Determine the moment of inertia of the resulting composite figure about the centroidal X axis. (14)



16 Three cables support a weight of 500 N at point A as shown in the figure. Determine the tension in the cables. (14)



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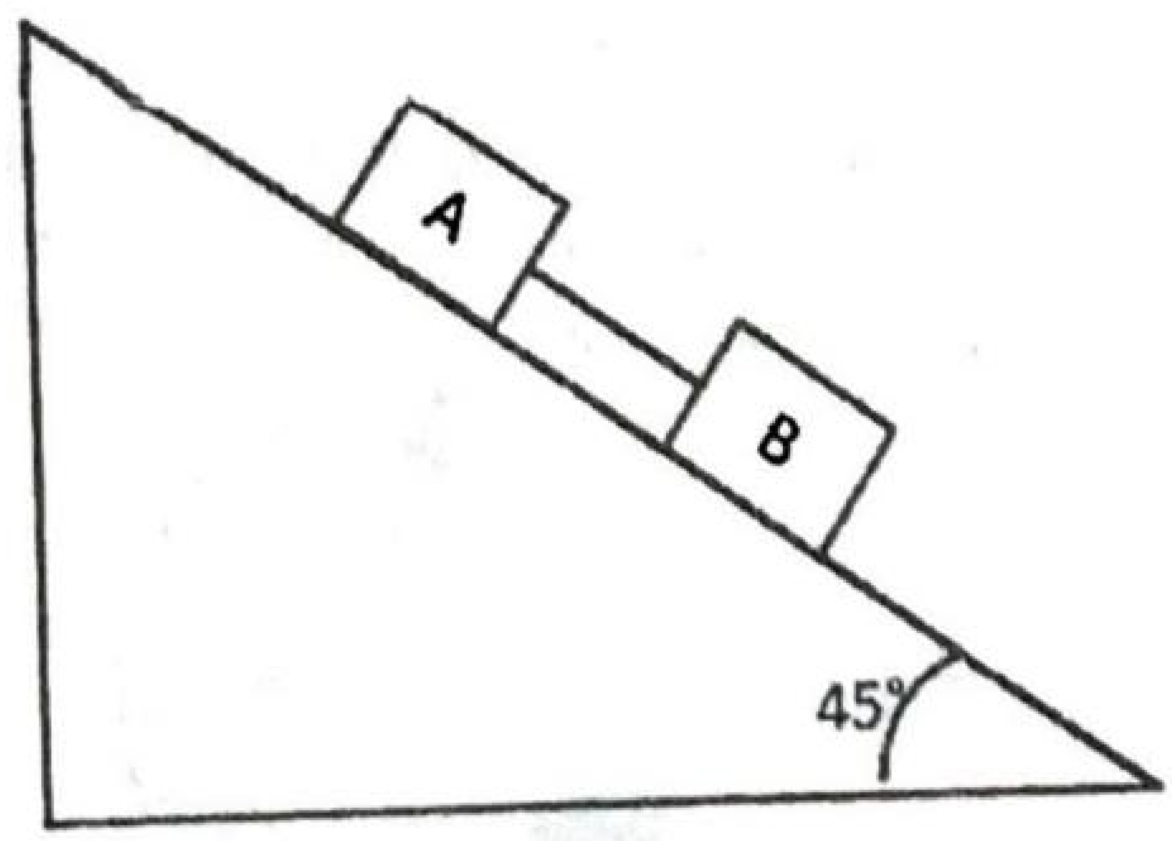
MODULE 4

17 a Two masses $M_A = 20$ kg and $M_B = 10$ kg are connected by a bar of negligible mass. Find the acceleration of the system when it slides down an inclined plane of inclination 45° as shown in figure. Also find the force in bar. Assume $\mu_A = 0.2$ and $\mu_B = 0.4$. (10)



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17 b A car moving at a speed of 60kmph, when the brakes are fully applies causing all four wheel to skid. Determine the time required to stop the car. The coefficient of friction between the road and tyre is 0.3. Weight of the car 50kN. (4)

18 a A block of weight 50N is moving over a horizontal surface starting at rest, moves over a distance of 25m in 10 seconds under the action of a force of 20N. Determine the coefficient of friction between the surfaces. (7)

18 b A car starts from rest on a curved road of radius 250 m and attains a speed of 18 km/hour at the end of 60 seconds while travelling with a uniform acceleration. Find the tangential and normal accelerations of the car 30 seconds after it started. (7)

MODULE 5

19 a A particle moving with simple harmonic motion has velocities of 8 m/s and 4 m/s when at the distance of 1 m and 2 m from the mean position. Determine (i) amplitude, (ii) period, (iii) maximum velocity, and (iv) maximum acceleration of the particle. (7)

19 b A weight of 50 N suspended from a spring vibrates vertically with an amplitude of 7.5cm and a frequency of 1oscillation /second. Find the stiffness of the spring and the maximum tension induced in the spring (7)

20 a A weight of 4 N is suspended by a light rope wound round a pulley of weight 48 N and radius 25 cm, the other end of the rope being fixed to the periphery of the pulley. If the weight is moving downwards, determine: (7)

(i) Acceleration of the weight 4 N, and

(ii) Tension in the string. Take $g = 9.80\ m/s^2$.

20 b A wheel, rotating about a fixed axis at 30 r.p.m. is uniformly accelerated for 50 seconds, during which time it makes 40 revolution. Find: (i) angular velocity the end of this interval, and (ii) time required for the speed to reach 80 revolution per minute. (7)

****

1) * Collinear forces :-

Line of action of all forces act along the same line.

* Coplanar parallel forces :-

All forces are parallel to each other and lie in a single plane.

* Coplanar like parallel forces :-

All forces are parallel to each other, lie in a single plane and are acting in the same direction.

* Coplanar concurrent forces :-

Line of action of all forces pass through a

* Coplanar non-concurrent forces :-

All forces do not meet at a point, but lie in a single point

* Non-coplanar parallel forces :-

All forces are parallel to each other, but not in same plane.

* Non-coplanar concurrent forces :-

All forces do not lie in the same plane, but their line of action pass through a single point

* Non-coplanar non-concurrent forces :-

All forces do not lie in the same plane and their lines of action do not pass through a single point.

2)

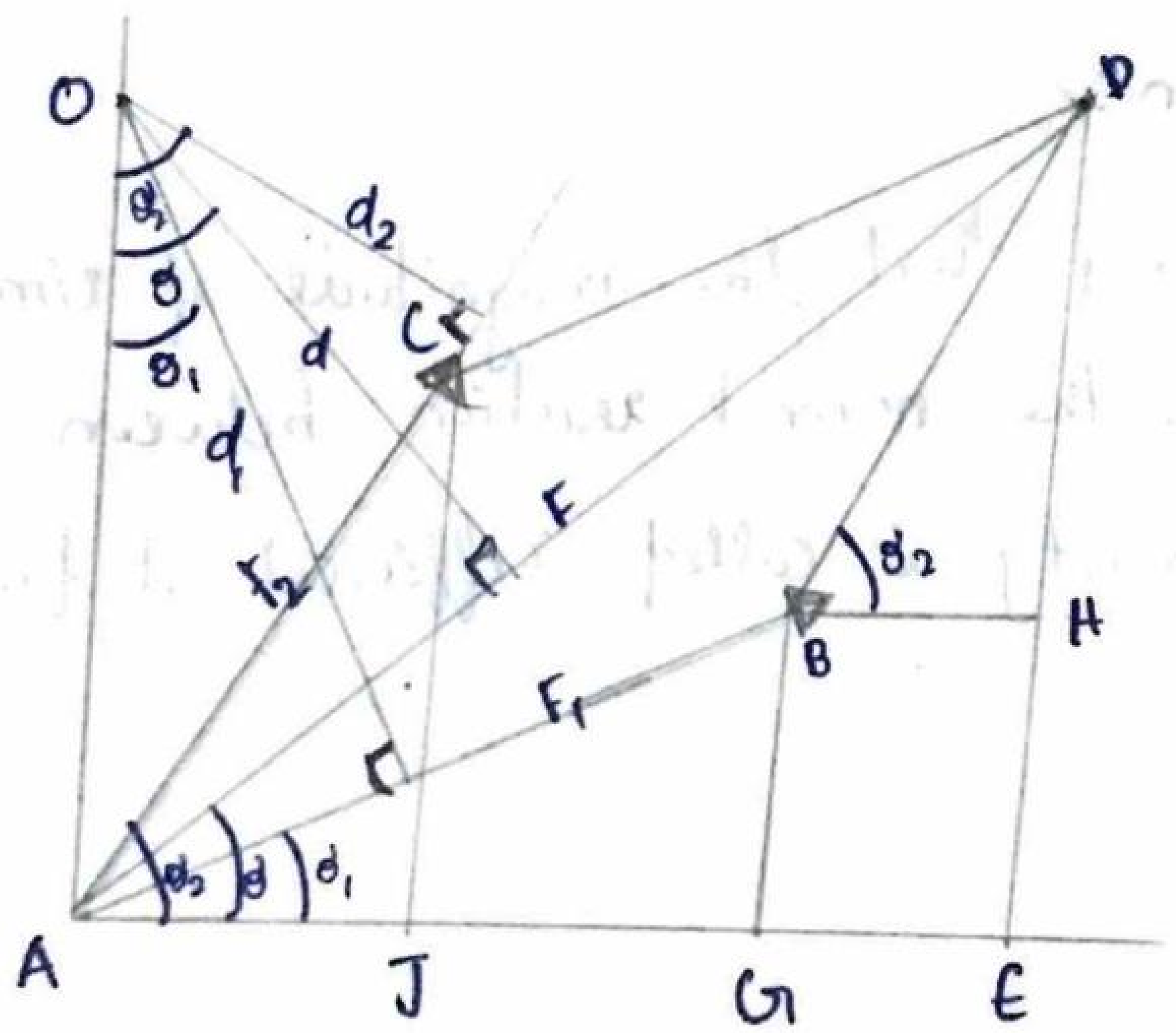
Varigon's theorem:-

The moment of a force about any point is equal to the algebraic sum of moment of its component about that point.

Proof:-

Consider a force F acting at a point A.

Moment of $F = F \times d$



F_1 & F_2 are components of F

d_1 & d_2 are arms of F_1 & F_2

From the fig,

$AE = AG + GE$

$= AG + BH$

$= AG + BD\cos\theta_2$

$= AG + AC\cos\theta_2$

$AD\cos\theta = AB\cos\theta_1 + AC\cos\theta_2$

$F\cos\theta = F_1\cos\theta_1 + F_2\cos\theta_2$ &

Multiplying by OA,

$F \times OA\cos\theta = F_1 \times OA\cos\theta_1 + F_2 \times OA\cos\theta_2$

$$\boxed{\therefore F \times d = F_1 \times d_1 + F_2 \times d_2}$$

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3) Coefficient of friction:-

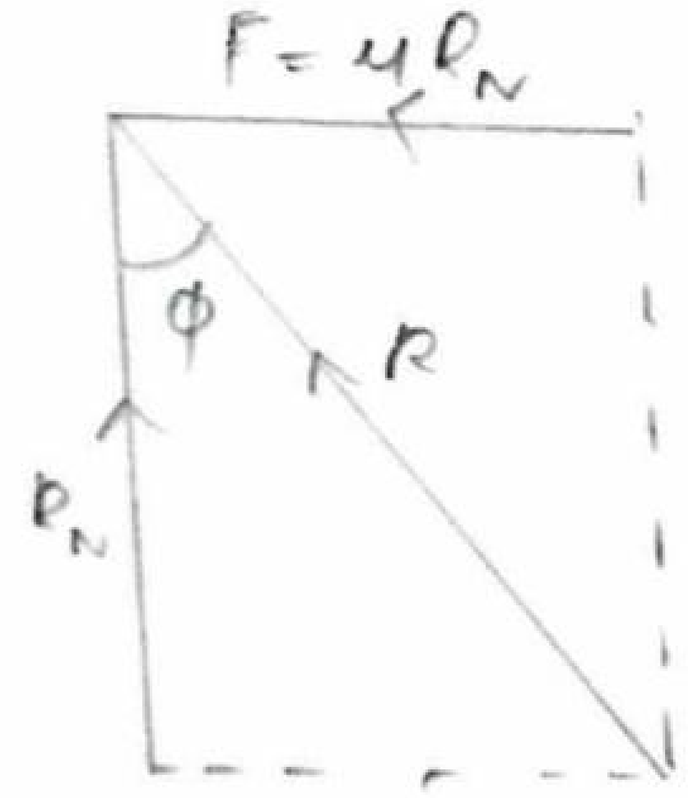
- It is experimentally found that the magnitude of limiting frict bears a const. ratio to the normal reaction between two surfaces. This const of proportionality is called coefficient of friction.

$$F \propto R_n$$

$$F = \mu R_N$$

$$\mu = F/R_N$$

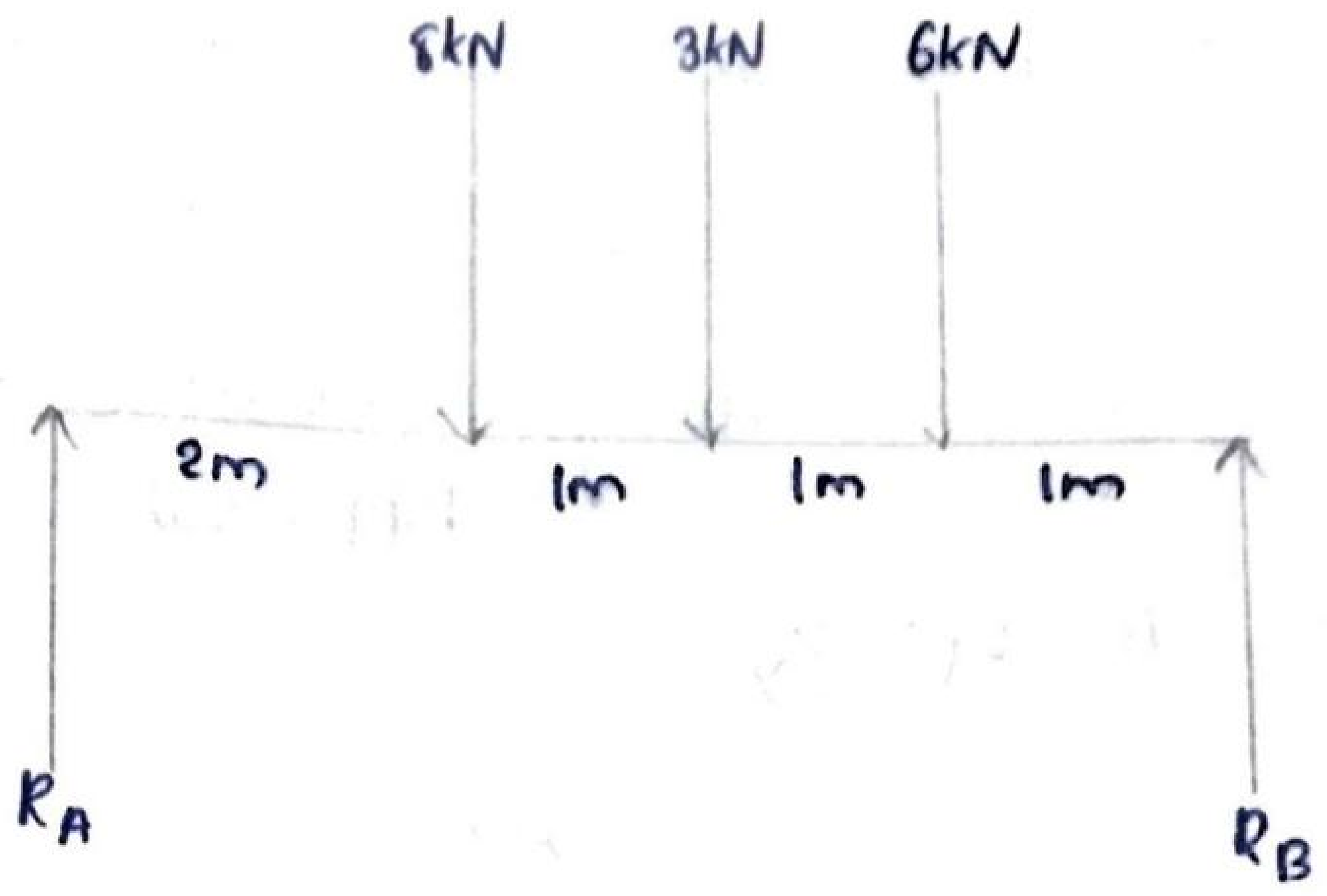
Here ϕ is the angle of friction.



$$\tan\phi = \frac{F}{R_N} = \frac{\mu R_N}{R_N}$$

$$\therefore \tan\phi = \mu$$

4)



System is in equillibrium

$\Sigma F_v = 0$

$R_A - 8 - 3 - 6 + R_B = 0$

$R_A + R_B = 15$ —— ①

taking moment about A

$\Sigma M_A = 0$

$\Sigma M_A \Rightarrow 8 \times 2 + 3 \times 3 + 6 \times 4 \times 5 \times R_B = 0$

$16 + 9 + 24 - 5R_B = 0$

$5R_B = 49$

$R_B = \frac{49}{5} = \underline{9.8kN}$

Sub R_B in ①

$R_A + 9.8 = 15$

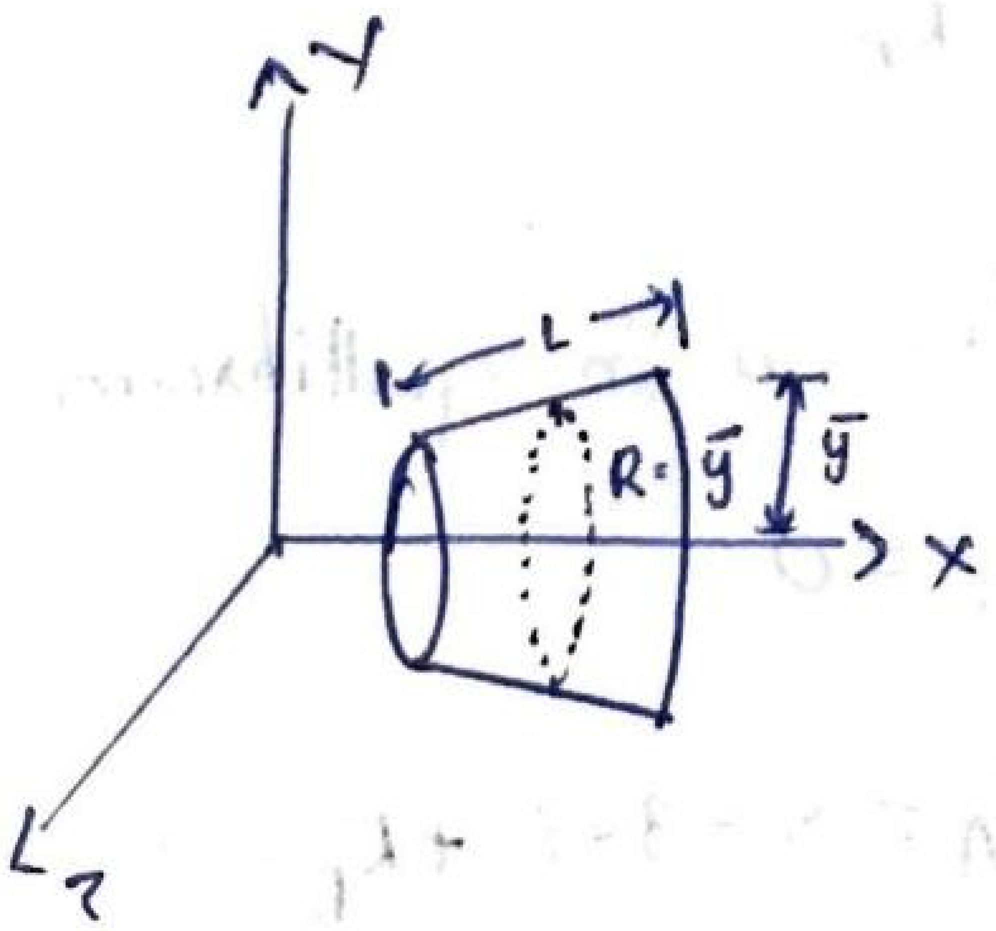
$R_A = 15 - 9.8$

$R_A = \underline{5.2kN}$

5) The area of surface generated by revolving a plane about a non-intersecting axis in the plane of the curve is equal to the product of the length of the curve and the distance travelled by the centroid G of the curve during the revolution.

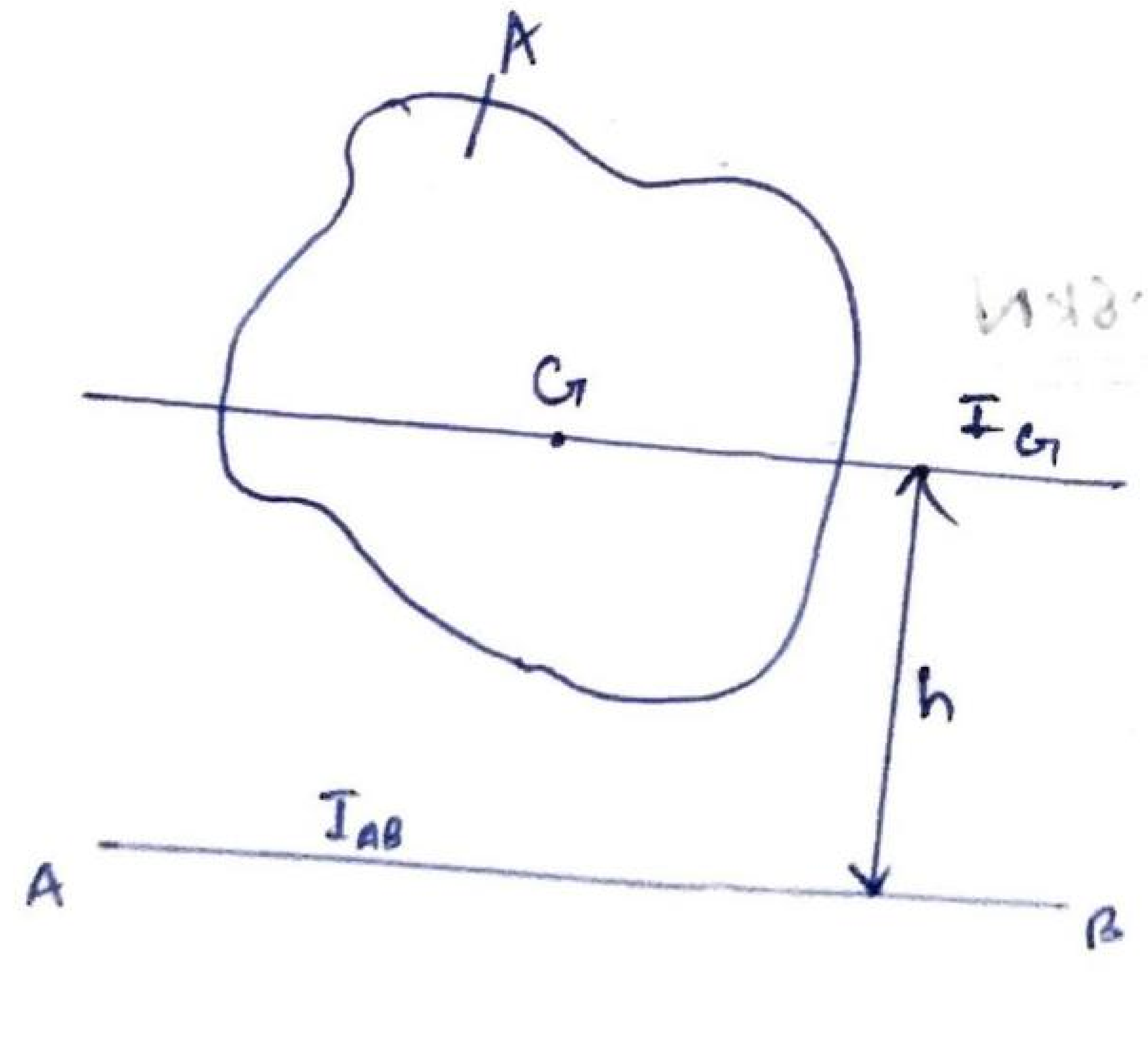
(PapPus Guldinus Theorem 1)

$$\text{Area} = A = L(2\pi)\bar{y}$$



6) Parallel Axis theorem:-

It states that if I_G is the moment of inertia of plane lamina of area A, about its centroidal axis in the plane of the lamina, then the moment of inertia about any axis AB which is parallel to the centroidal axis and at a distance 'h' from the centroidal axis is given by $I_{AB} = I_G + Ah^2$



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7) D'Alembert's principle states that the resultant of a system of force acting on a body in motion is in dynamic equillibrium with the inertia force (

$$F + (-ma) = 0$$

Also, $F_{net} + F_{inertia} = 0$

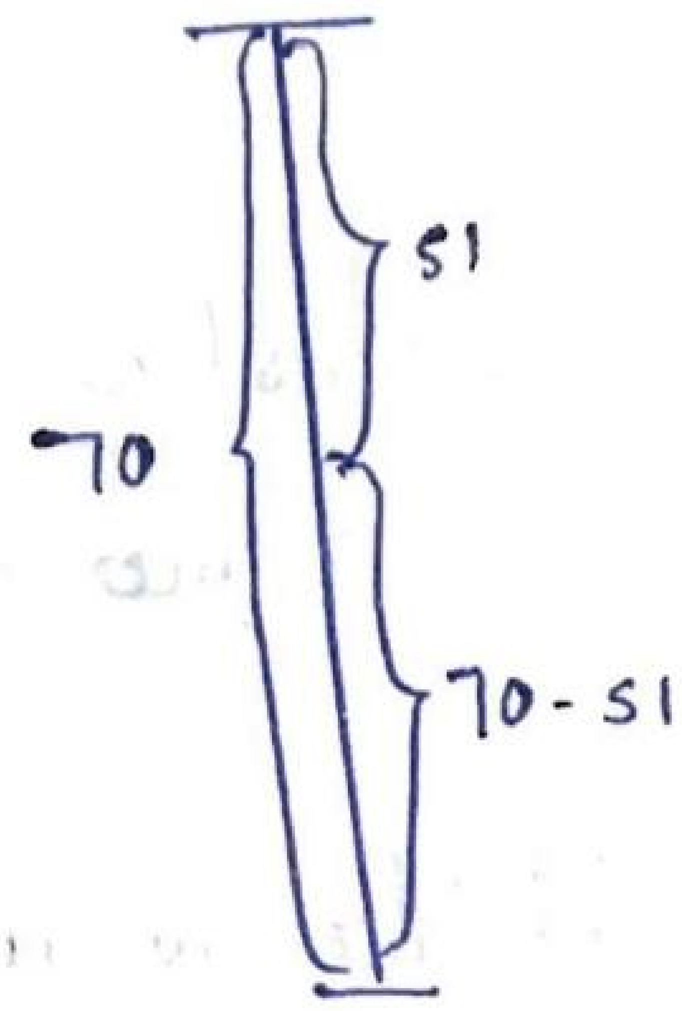
It is used for analysing the dynamic ~~problems~~ problem which can reduce it into static equillibrium problem.

8)

Let the dropped stone 'A' & thrown be 'B'

A is in free fall

$\therefore$ initial Velocity, $u = 0$



Distance travelled by stone A from the top of tower is

$$S_1 = ut + \frac{1}{2}at^2$$

$$S_1 = \frac{1}{2}at^2$$

for same stone 'A', distance from foot of solid is

$$S = 70 - S_1$$

$$S = 70 - \frac{1}{2}at^2$$

For stone 'B', distance from foot of towu is

$$S = ut + \frac{1}{2}at^2 \qquad u = 30$$

$$S = 30t - \frac{1}{2}at^2 \qquad a = -a \text{ (retardation)}$$

Stone 'A' and stone 'B' will meet at the same distance from the foot of tower

$\therefore$ $70 - \frac{1}{2}at^2 = 30t - \frac{1}{2}gt^2$

$30t = 70$

$t = \frac{70}{30} = 2.3s$

distance stone cross each other from ground

$= 70 - \frac{1}{2}(9.8)(2.3)^2$ $\quad a = 9.8$, $t = 2.3$

$= 70 - 25.92$

$= \underline{44.08m}$

$\therefore$ The stone cross each other at a distance 44.08 from foot of tower and at 2.3s

9) Instantaneous centre about which every point on a moving link is assumed to be in pure rotational motion

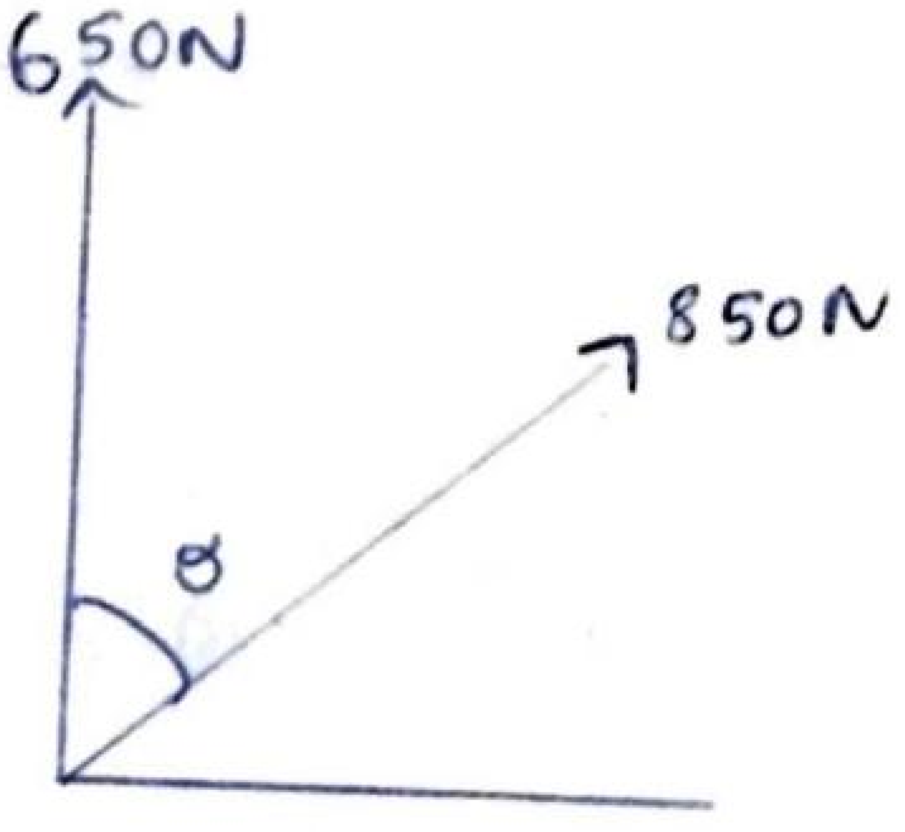
The combined motion of rotation and translation, maybe assumed to be a motion of pure rotation about some centre. As the position of link AB goes on changing, therefore the centre, about which the motion of rotation is assumed to take place, also goes on changing. Such a centre, which goes on changing from one instant to another is known as instantaneous center

10) In general plane motion, bodies are both rotating and translating at the same time.

eg:- (i) Bar sliding down wall

(ii) Rolling wheel

11)



$1300^2 = 850^2 + 650^2 + 2 \times 850 \times 650 \times \cos\theta$

$1690000 = 722500 + 422500 + 1105000 \cos\theta$

$545000 = 1105000 \cos\theta$

$\cos\theta = 10.4932$

$\theta = 60.44$

angle b/w two forces = 60.44

$F_x = 850 \times \sin(60.44) = 739.36\,N$

$F_y = 650 + 850 \cos(60.44) = 1069.34\,N$

$\tan\theta_R = \dfrac{1069.34}{739.36}$

$\tan\theta_R = 1.446$

$\theta_R = 55.33 \rightarrow$ dirn of resultant

11 b)

$\angle BC = \tan^{-1}\left(\frac{3}{4}\right) = 36.87^{\circ}$

$\Sigma F_x = 310\cos 35 + 280 + 250 \cos 36.87$

$= 733.936 kN$

$\Sigma F_y = -310\sin 35 + 250\sin 36.87 + 150$

$= 122.2 kN$

$R = \sqrt{(733.936)^2 + (122.2)^2}$

$R = 744.04 kN$

$\tan\theta_R = \frac{F_y}{F_x}$

$\theta_R = \tan^{-1}\left[\frac{122.2}{733.936}\right]$

$\theta_R = 9.453$

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12) Consider Δ^{le} ABC

$AC = 40 + 60$

$= 100\,mm$

$AB = 190 - (40+60)$

$= 90\,mm$

~~$\cos\theta = \frac{AB}{AC}$~~

~~$= \frac{100}{90}$~~

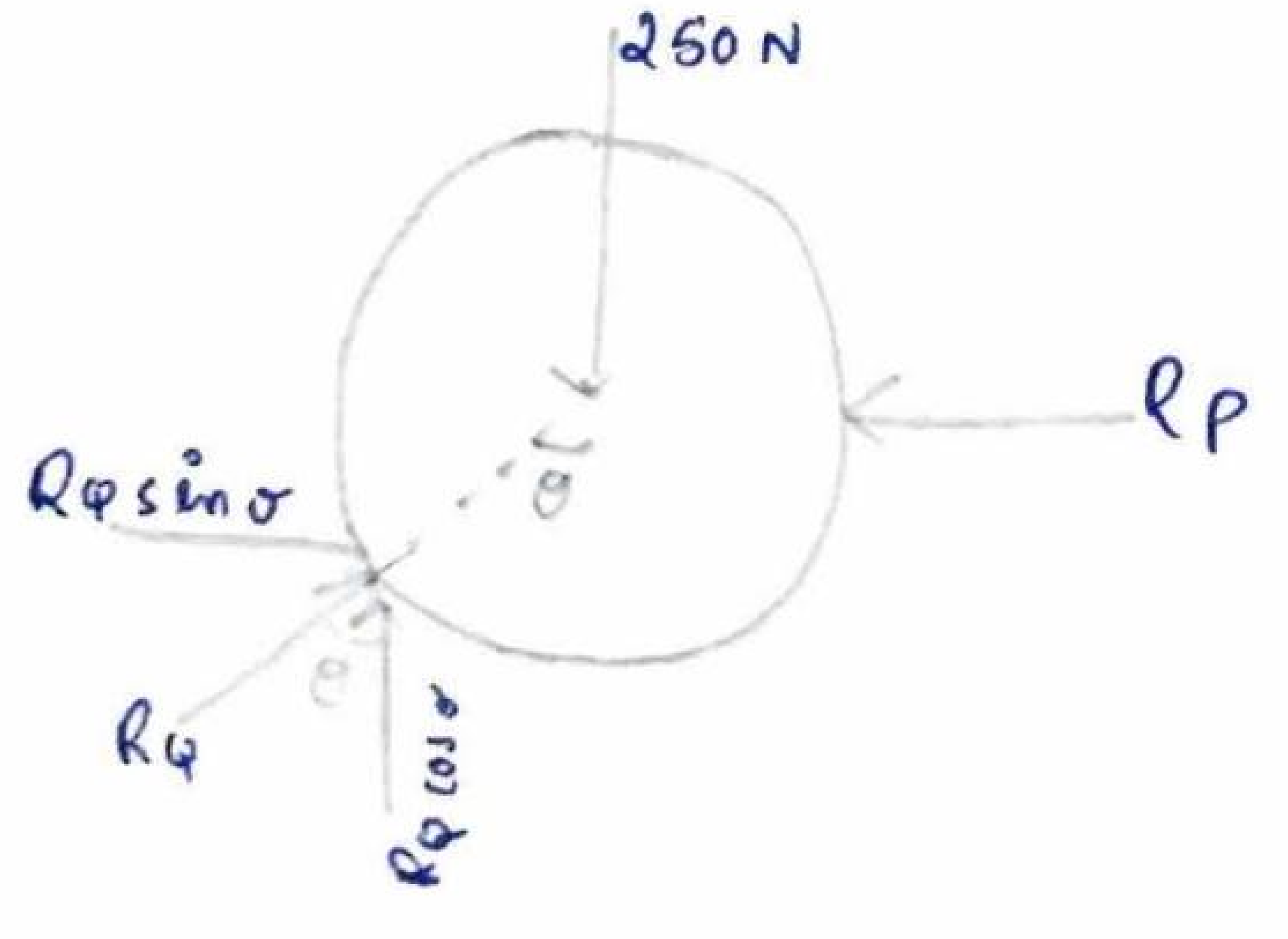
$=$

$\sin\theta = \frac{AB}{AC}$

$\sin\theta = \frac{90}{100} = 0.9$

$\theta = 64.16^\circ$

Consider the eqlbrium of sphere 2



$\Sigma F_H = 0$

$R_Q\sin\theta - R_P = 0$

$R_Q\sin\theta = R_P$

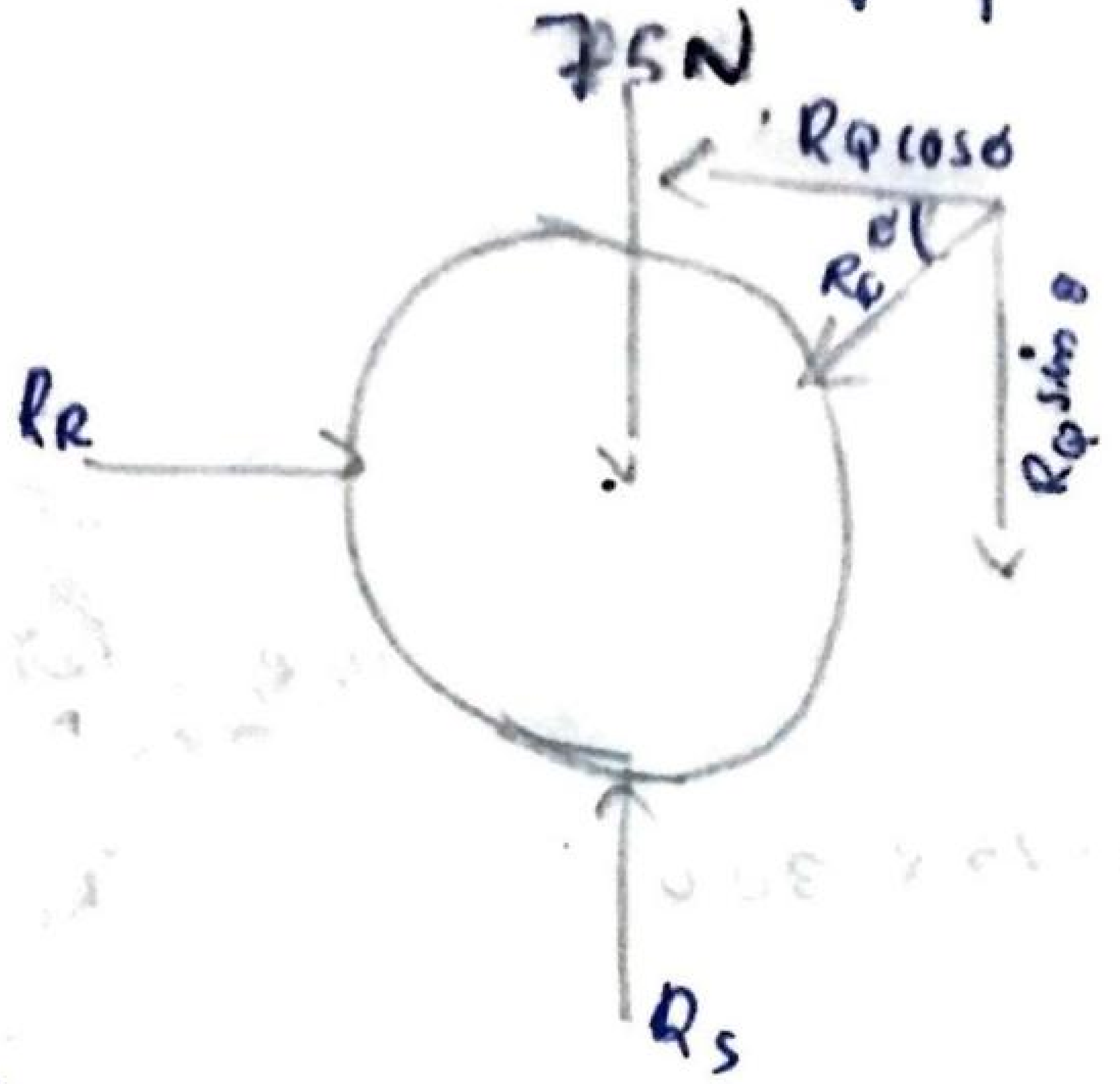
$\Sigma F_V = 0$

$R_Q\cos\theta - 250 = 0$

$R_Q\cos\theta = 250\,N$ $\qquad R_Q\cos 64.16^\circ = 250$

$R_Q = 573.56\,N$

consider the ~~spher~~ eqlbrm of sphere 1



$\Sigma FH = 0$

$R_Q \cos\theta = R_R$

$R_R = 537.58$

$\Sigma FV = 0$

$R_S - 75 - R_Q \sin\theta = 0$

$R_S = 75 + R_Q \sin\theta$

$= 75 + 516.23$

$R_S = 591.25 N$

$R_P = R_Q \sin\theta$

$= 516.23 N$

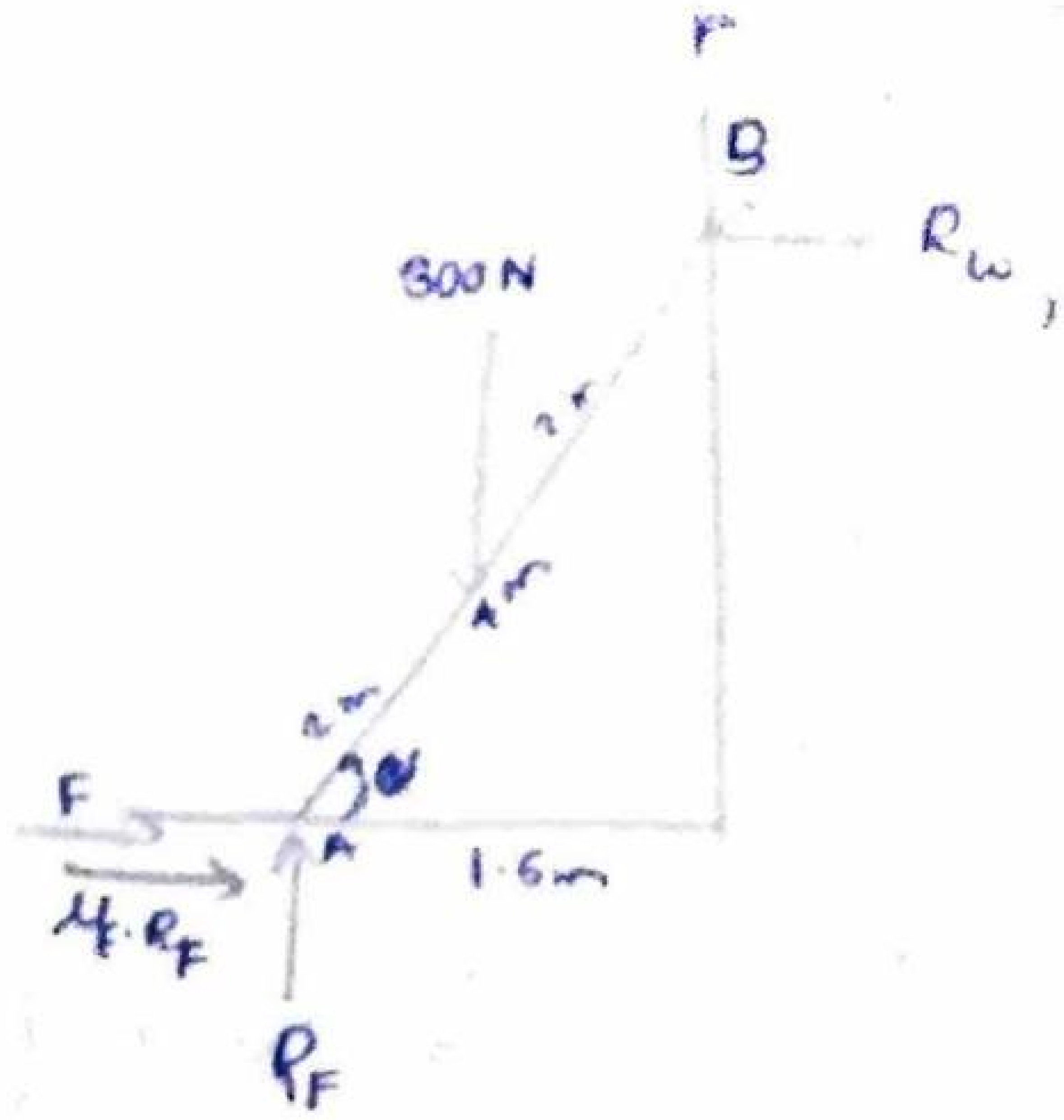
13)

a) $\Sigma F_V = 0$

$R_F = 300$

$\therefore$ frictional force acting at point of contact of ladder and floor $= 0.25 \times 300$

$\mu_f \cdot R_f = 75N$



Taking moment about A, $\Sigma M = 0$

$\theta = \cos^{-1} \frac{1.5}{4}$

$= 68^0$

$300 \times \cos 68^0 - R_w \times \sin 68^0 = 0$

$0.927 R_w = 112.38$

$R_w = 121.23$

b) $\Sigma F_H = 0$

$F + \mu_f \cdot R_f - R_w = 0$

$F + 75 - 121.23 = 0$

$F - 46.23 = 0$

$F = 46.23 N$

Since $F < \mu_f \cdot R_f$, the ladder will be in eqlbrm.

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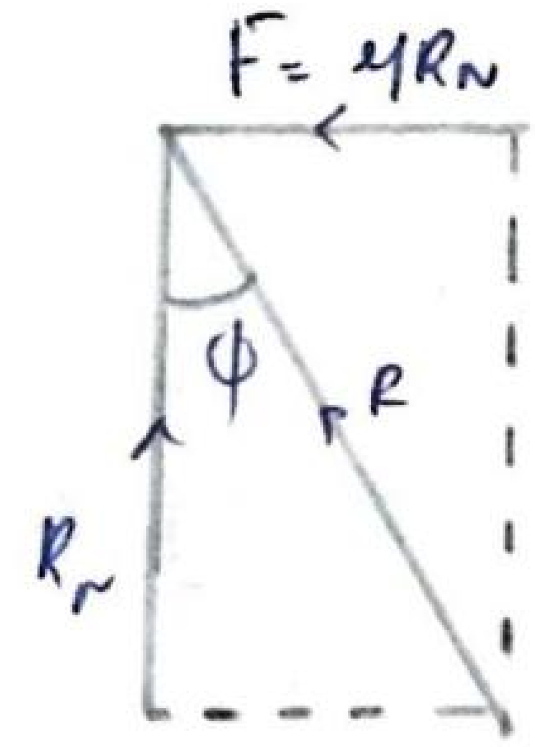
13 b) Angle of friction :-

It is the angle between the normal reaction at the contact surface and the resultant of normal reaction and limiting friction. It is denoted by ϕ

$$\cancel{\tan\phi} = \cancel{\frac{F}{R_N}} = \cancel{\frac{\mu R_N}{+}}$$

Angle of repose :-

It is the maximum inclination of a plane, on which a body tends to repose without applying external force



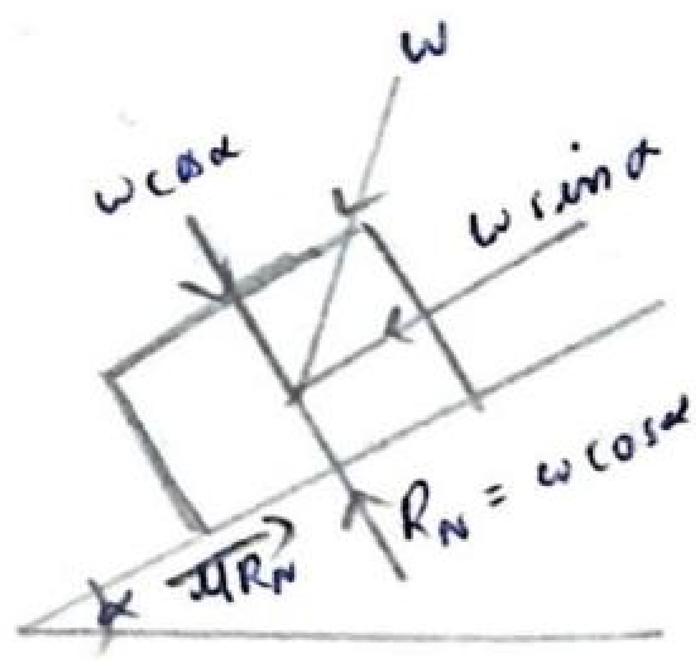
$$\tan\phi = \frac{F}{R_N} = \frac{\mu R_N}{R_N} = \mu$$

Angle of friction $\phi = \tan^{-1}\mu$

- Resolving forces along the inclined plane

$$\mu R_N - W\sin\alpha = 0$$

$$\mu R_N = W\sin\alpha \quad \text{--- (1)}$$



Resolving forces perpendicular to inclined plane

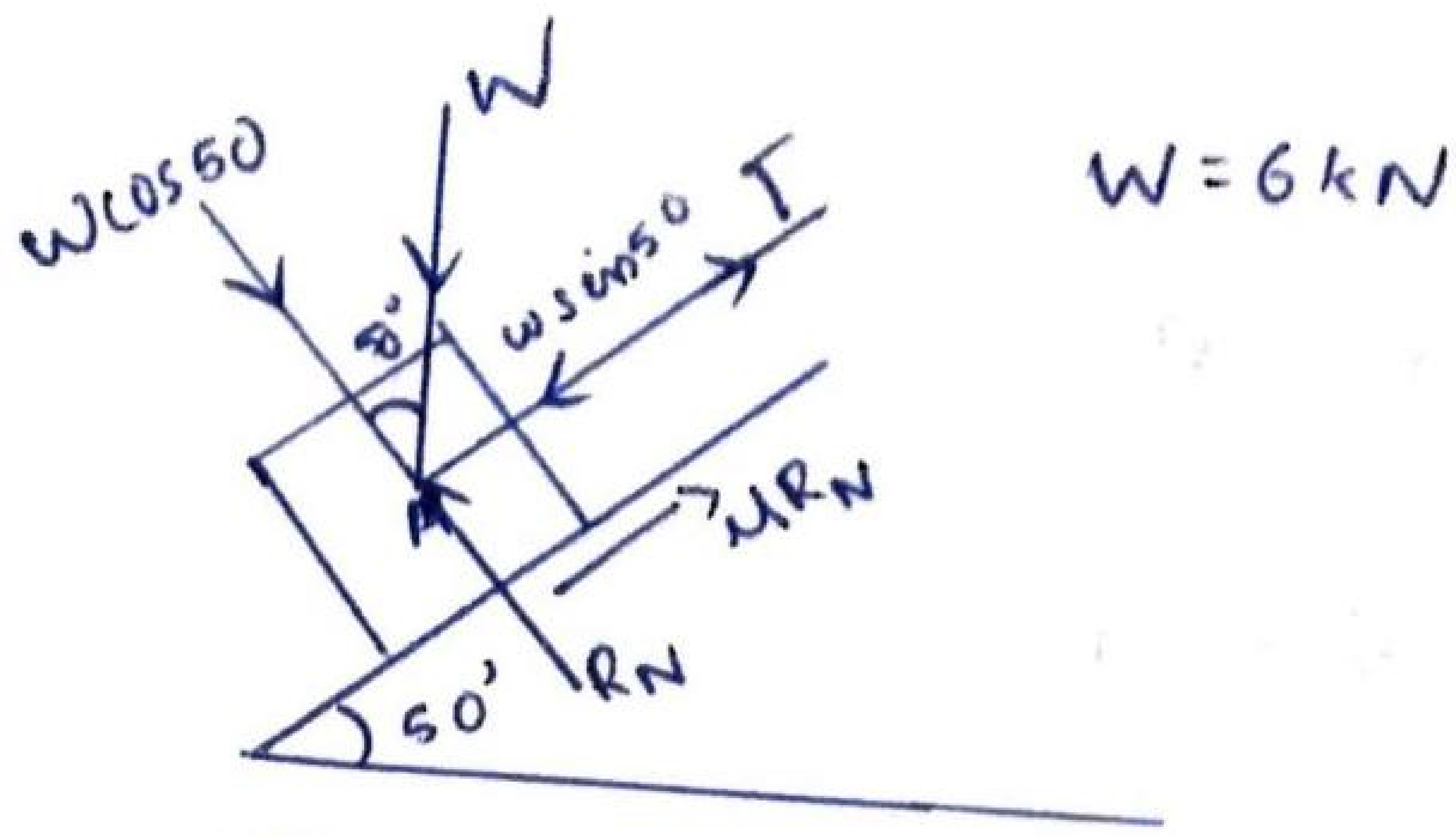
$$R_N = W\cos\alpha \quad \text{--- (2)}$$

(1) ÷ (2) => $\tan\alpha = \mu$

$$\alpha = \tan^{-1}\mu$$

$$\alpha = \phi$$

14) consider block A



resolving forces $\perp^{ar}$ to inclined plane

$R_N - W\cos 50 = 0$

$R_N = W\cos 50$

$= 6 \times 0.642$

$= 3.86\ kN$

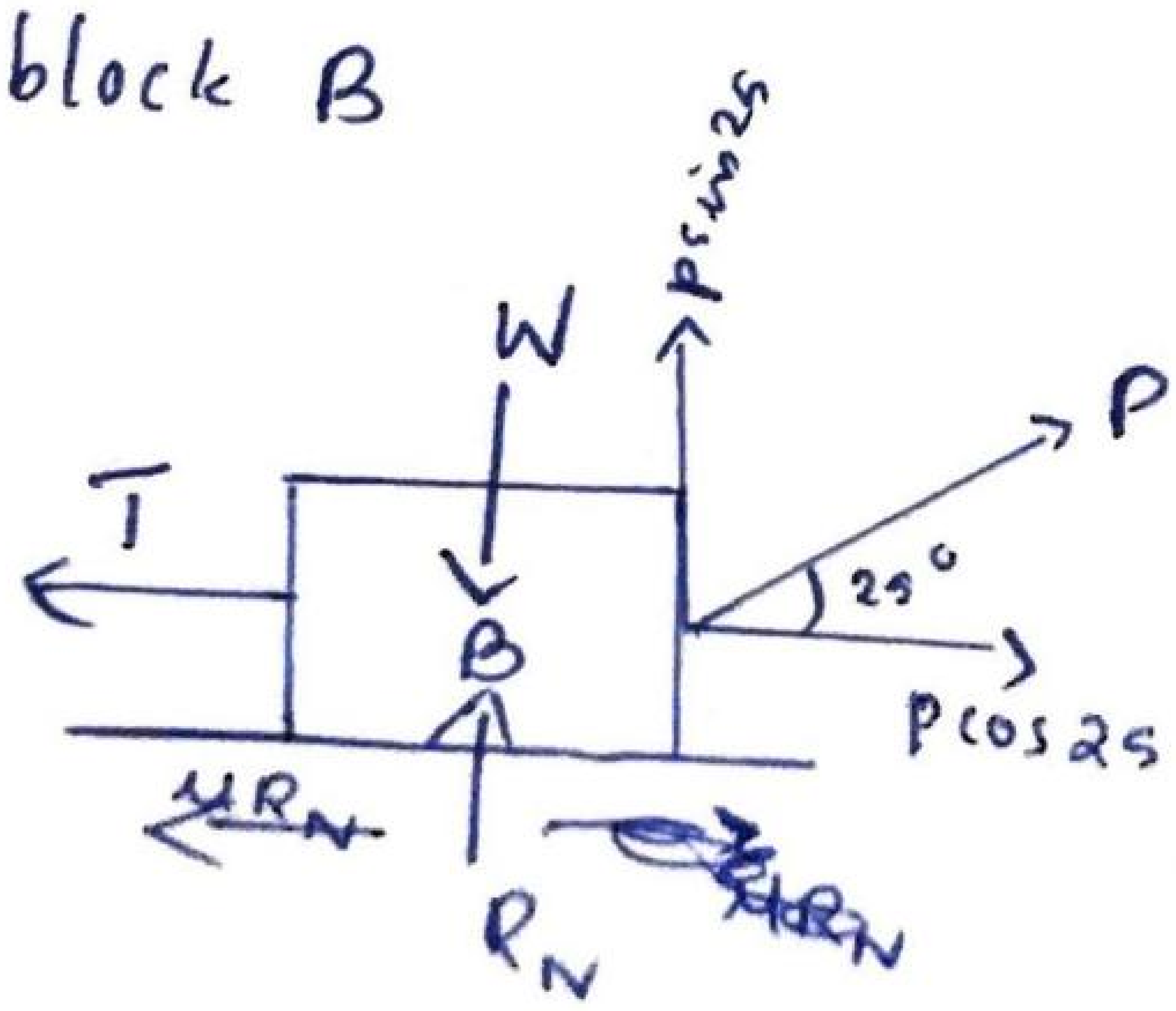
resolving forces $\parallel^{al}$ to inclined plane

$T + \mu R_N - W\sin 50 = 0$

$T + 0.2 \times 3.86 - 6 \times 0.77 = 0$

$T = 3.848\ kN$

Consider block B



$P\cos 25 - T = 0$

$\Sigma F_V = 0$

$R_N + P\sin 25 - W = 0$

$R_N + 0.42P - 3.5 = 0$

$R_N = 3.5 - 0.42P$

$\Sigma F_H = 0$

$P\cos 25 = 4R_N + T$

$P\cos 25 = 0.2(3.5 - 0.42P) + 3.848$

$0.91P = 0.7 - 0.084P + 3.848$

$0.994P = 4.548$

$P = 4.58\,kN$

15)

$a_1 = \pi r^2 = \pi \times 4^2 = 50.27\, m^2$

$a_2 = \pi r^2 = \pi \times 2^2 = 12.57\, m^2$

$a_3 = \dfrac{\pi r^2}{4} = \dfrac{\pi \times 2^2}{4} = 3.14\, m^2$

$x_1 = d/2 = 4/2 = 2$

$x_2 = 1 + d/2 = 1 + 2/2 = 2$

$x_3 = 2 + \dfrac{4R}{3\pi} = 2 + \dfrac{4 \times 1}{3\pi} = 2.42$

$y_1 = d/2 = 4/2 = 2$

$y_2 = 1 + d/2 = 1 + 2/2 = 2$

$y_3 = 2 + \dfrac{4R}{3\pi} = 2.42$

$\bar{x} = \dfrac{a_1x_1 - a_2x_2 + a_3x_3}{a_1 + a_2 + a_3} = 1.26\, m$

$\bar{y} = \dfrac{a_1y_1 - a_2y_2 + a_3y_3}{a_1 + a_2 + a_3} = 1.26\, m$

Since $\bar{x}$ & $\bar{y}$ are same, G_1, G_2, G_3 & G are on the same XX axis

$$I_{G_{xx}} = I_{G_{1xx}} - I_{G_{2xx}} + I_{G_{3xx}}$$

$$I_{G_1xx} = \frac{\pi d^4}{64} = \frac{\pi \times 4^4}{64} = 12.57$$

$$I_{G_2xx} = \frac{\pi d^4}{64} = \frac{\pi \times 2^4}{64} = 0.79$$

$$I_{G_3xx} = \frac{\pi d^4}{256} = \frac{\pi \times 2^4}{256} = 0.196$$

$$I_{G_{xx}} = 12.57 - 0.79 + 0.196$$

$$= \underline{\underline{11.976 m^4}}$$

1c) coordinates

A(0, -8, 0)

B(4, 0, 0)

C(0, 0, 2)

D(-1, 0, -3)

O(0, 0, 0)

$x_A = 0$ $y_A = -8$ $z_A = 0$

$x_B = 4$ $y_B = 0$ $z_B = 0$

$x_C = 0$ $y_C = 0$ $z_C = 2$

$x_D = -1$ $y_D = 0$ $z_D = -3$

$d_{AB} = \sqrt{\cancel{(0-4)^2} \quad (4-0)^2 + (0-{-8})^2 + (0-0)^2}$

$= \sqrt{16 + 64}$

$= 8.9 m$

$d_{AC} = \sqrt{(0-0)^2 + (0-{-8})^2 + (2-0)^2}$

$= \sqrt{64 + 4}$

$= 8.3 m$

$d_{AD} = \sqrt{(1-0)^2 + (0-{-8})^2 + (-3-0)^2}$

$= \sqrt{1 + 64 + 9}$

$= 8.6 m$

unit vector along $AB = \dfrac{(4-0)\hat{i} + (0-{-8})\hat{j} + (0-0)\hat{k}}{8.9}$

$= \dfrac{4\hat{i} + 8\hat{j}}{8.9}$

unit vector along $AC = \dfrac{(0-0)\hat{i} + (0-{-8})\hat{j} + (2-0)\hat{k}}{8.3}$

$= \dfrac{8\hat{j} + 2\hat{k}}{8.3}$

Unit vector along AD = $\dfrac{(-1-0)\hat{i} + (0-8)\hat{j} + (-3-0)\hat{k}}{8.6}$

$$= \frac{-\hat{i} + 8\hat{j} - 3\hat{k}}{8.6}$$

$$F_{AB} = \left(\frac{4\hat{i} + 8\hat{j}}{8.9}\right) T_{AB}$$

$$= (0.45\hat{i} + 0.9\hat{j})\, T_{AB}$$

$$F_{AC} = \left(\frac{8\hat{j} + 2\hat{k}}{8.3}\right) T_{AC}$$

$$= (0.96\hat{j} + 0.24\hat{k})\, T_{AC}$$

$$F_{AD} = \left(\frac{-\hat{i} + 8\hat{j} - 3\hat{k}}{8.6}\right) T_{AD}$$

$$= (-0.12\hat{i} + 0.93\hat{j} - 0.35\hat{k})\, T_{AD}$$

Let the weight at A be P

F along P = $0\hat{i} - 500\hat{j} + 0\hat{k}$

$$\sum F_x = 0$$

$$0.45 \times T_{AB} - 0.12 \times T_{AD} = 0, \quad T_{AB} = 0.27\, T_{AD} \quad \text{—— (1)}$$

or

$$\sum F_y = 0$$

$$0.9 \times T_{AB} + 0.96 \times T_{AC} + 0.93 \times T_{AD} - 500 = 0 \quad \text{—— (2)}$$

$\Sigma F_z = 0$

$0.24 \times T_{AC} - 0.35 \times T_{AD} = 0$

$T_{AC} = 1.46\, T_{AD}$ — (3)

Sub (3) & (1) in (2)

$0.9 \times 0.27 T_{AD} + 0.96 \times 1.46\, T_{AD} + 0.93\, T_{AD} = 500$

$2.575\, T_{AD} = 500$

$T_{AD} = 194.17 N$ — (4)

Sub (4) in (1)

$T_{AB} = 0.27 \times 194.17$

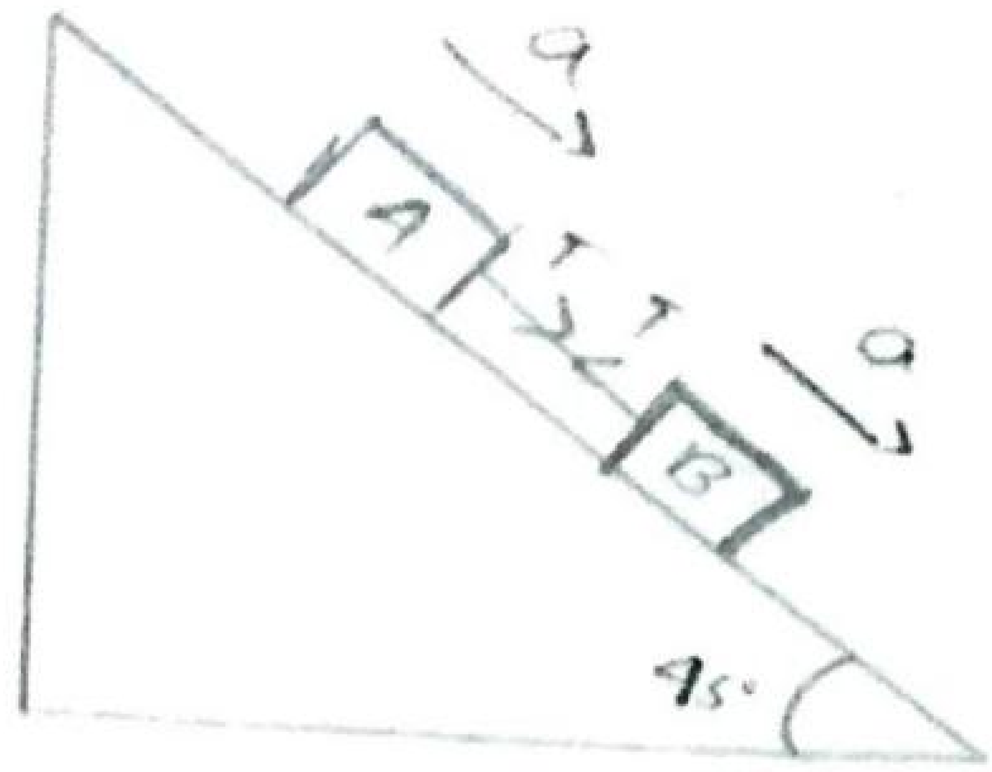
$= 52.43 N$

Sub (4) in (3)

$T_{AC} = 1.46 \times 194.17$

$= 283.49 N$

17 a)

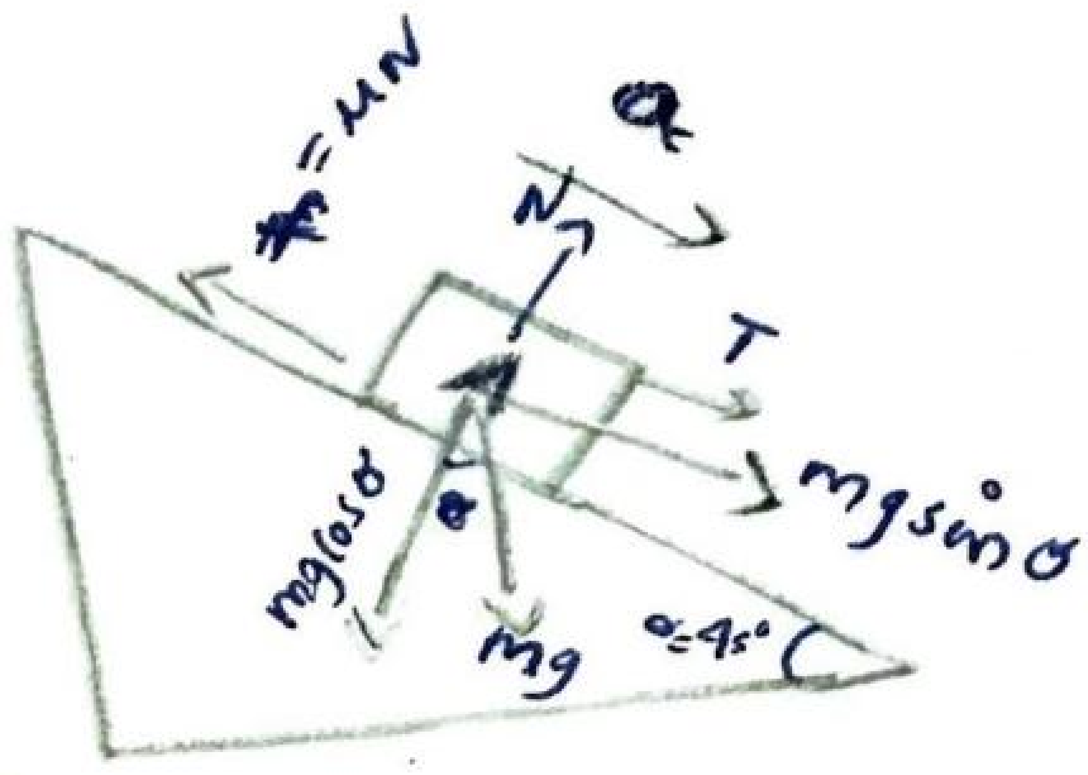


Consider Block A

$\Sigma F_H = F$

$F = m_a g \sin\theta + T - f$

$20a = 20g\sin 45 + T - 0.2(20g\cos 45)$ — ①

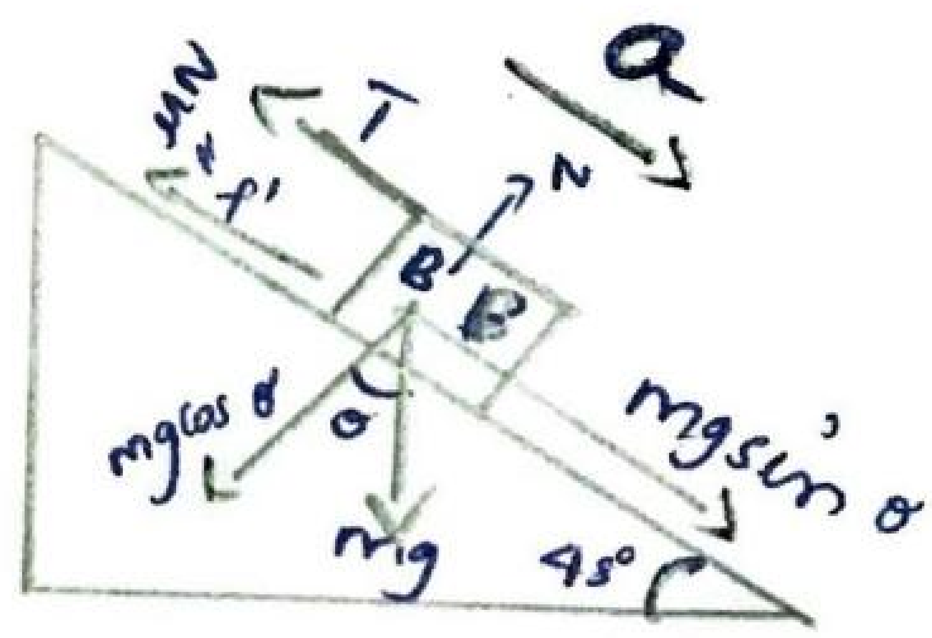


Consider Block B

$F = m_B g\sin\theta - T - f'$

$10a = 10g\sin 45 - T - 0.4(10g\cos 45)$

$10a = 10g\sin 45 - T - 0.4(10g\cos 45)$ — ②



Eqn ① + ② =>

$30a = 30g\sin 45 - 0.4(10g\cos 45) - 0.2(20g\cos 45)$

$30a = 207.89 - 27.72 - 27.72$

$30a = 152.45$

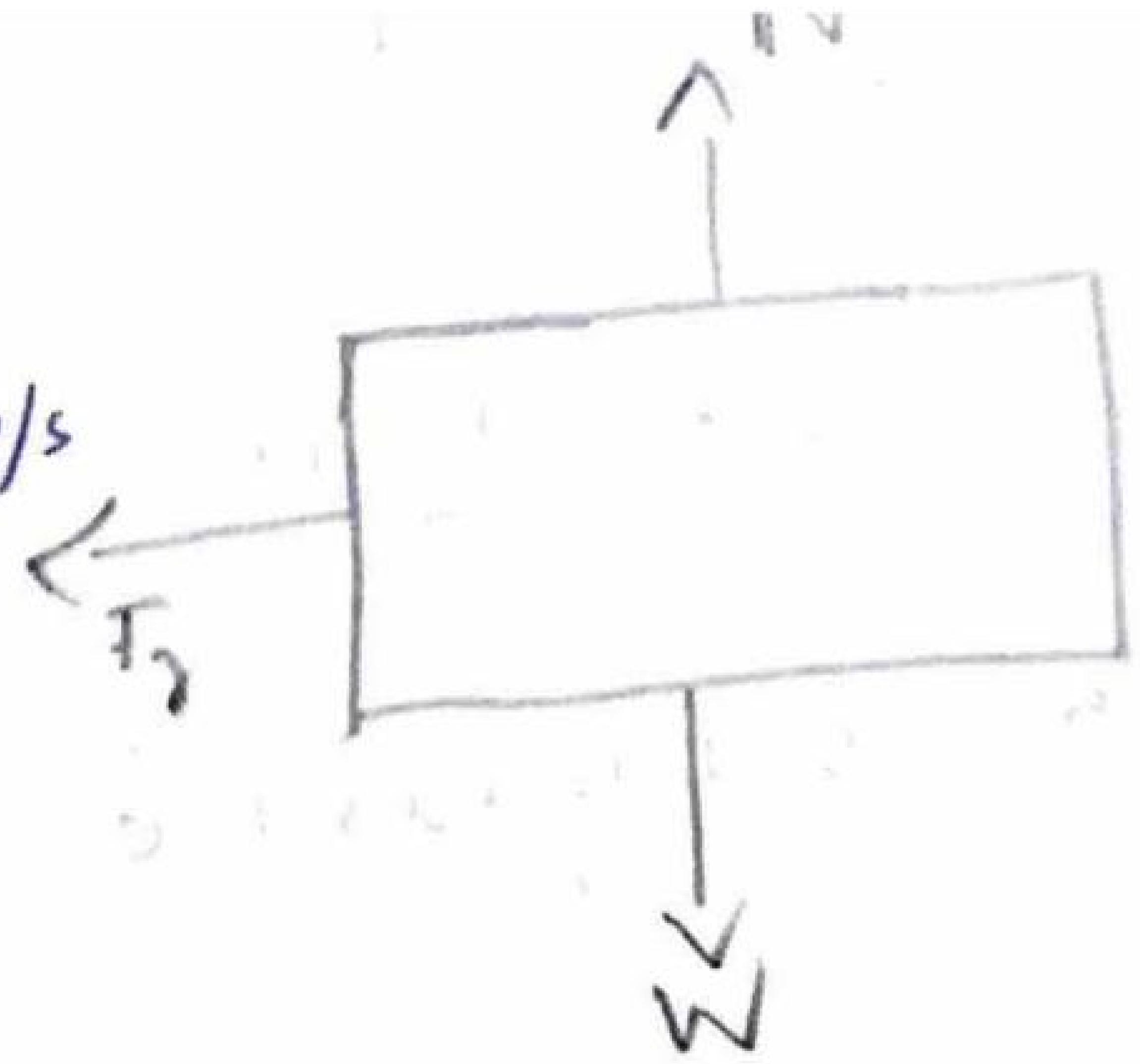
$a = 5.06\ m/s^2$

17 b) $W = \cancel{20}\ 50\,kN$

$u = \overset{60}{\cancel{70}}\,kmph = \overset{60}{\cancel{70}} \times \frac{5}{18}\,m/s = 16.67\,m/s$

$V = 0$ (stopping)

$\mu = 0.3$



$\Sigma V = 0$

$W = N$ — ①

$\Sigma H = 0$

$F_r = 0$

$F_r = \mu N$ — ②

Here net force is frictional force

$F = F_r$

$ma = \mu R$

$ma = \mu mg$

$a = \mu g$

$a = 0.3 \times 9.8 = 2.94\,m/s^2$

$V = u - at$

$0 = 16.67 - 2.94t$

$t = \frac{16.67}{2.94} = 5.67s$

18 a)

$S = ut + \frac{1}{2}at^2$

$u = 0$

$S = 25m$

$t = 10s$

$25 = 0 + \frac{1}{2} \times a \times \cancel{100}^{50}$

$50a = 25$

$a = 0.5 m/s^2$

Net force, $F = ma$

$W = mg$

$m = \frac{W}{g} = \frac{50}{9.8} = 5.1 kg$

$F = 5.1 \times 0.5$

$F = 2.55N$

Net force, $F = f - f_r$

$f = 20N$

$2.55 = 20 - f_r$

$f_r = 20 - 2.55$

$f_r = 17.45$

$f_r = 4N$ $\qquad N = W$

$17.45 = 50\mu$

$\mu = \cancel{\frac{50}{17.45}} \frac{17.45}{50}$

$\mu = \underline{0.35}$

18 b)

Car starts from rest

$V_1 = 0, \ \omega_1 = 0$

After 60s, $V_2 = 18\,km/hour = 18 \times \frac{5}{18}\ m/s$

$= 5\,m/s$

$V_2 = r \cdot \omega_2$

$\omega_2 = \frac{V_2}{r} = \frac{5}{250} = 0.002\ rad/s$

$\omega_2 = \omega_1 + \alpha t$

$0.002 = 0 + \alpha \times 60$

$\alpha = \frac{0.002}{60} = 3.3 \times 10^{-5}\ rad/s^2$

at $t = 30s$,

$\omega = \omega_1 + \alpha t$

$= 0 + (3.3 \times 10^{-5} \times 30)$

$= 1 \times 10^{-3}\ rad/s$

Tangential component of accelleration

$$a_t = r\alpha$$

$$= 250 \times 3.3 \times 10^{-5}$$

$$= 0.00825 \; m/s^2$$

Normal component of accellration

$$a_n = \omega^2 r$$

$$= (1 \times 10^{-3})^2 \times 250$$

$$= 0.00025 \; m/s^2$$

19 a) at $x = 1$, $V = 8 \, m/s$

at $x = 2$, $V = 4 \, m/s$

at $x = 1$

$$V = \omega\sqrt{r^2 - x^2}$$

$$8 = \omega\sqrt{r^2 - 1} \quad \text{— (1)}$$

at $x = 2$

$$4 = \omega\sqrt{r^2 - 4} \quad \text{— (2)}$$

(1) ÷ (2) => $2 = \dfrac{\sqrt{r^2 - 1}}{\sqrt{r^2 - 4}}$

$$4 = \frac{r^2 - 1}{r^2 - 4}$$

$$4r^2 - 16 = r^2 - 1$$

$$3r^2 = 15$$

$$r^2 = 5$$

$$r = 2.24\,m$$

(i) amplitude, $r = 2.24\,m$

(ii) sub $r = 2.24$ in (1)

$$8 = \omega\sqrt{(2.24)^2 - 1}$$

$8 = \omega$ $\quad \omega = 3.99\ rad/s$

Time period, $T = \frac{2\pi}{\omega} = \frac{2\pi}{3.99} = 1.58\,s$

$$T = \underline{1.58\,s}$$

(iii) $V_{max} = r\omega$

$$= 2.24 \times 3.99$$

$$= 8.94\ m/s$$

(iv) $a_{max} = \omega^2 r$

$$= (3.99)^2 \times 2.24$$

$$= 35.66\ m/s^2$$

19 b)

$m = \frac{W}{g} = \frac{50}{9.8} = 5.1\ kg$

$X = 7.5cm = 0.075\ m$

$f = 1$ oss/sec

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$f^2 = \frac{1}{4\pi^2} \times \frac{k}{m}$$

$$k = f^2 \times 4 \times \pi^2 \times m$$

$$= 1 \times 4 \times (3.14)^2 \times (5.1)$$

$$= 201.3\ N/m$$

Stiffnen of spring, $k = \underline{201.3\ N/m}$

Maximum tension induced in spring $= kX$

$$= 201.3 \times 0.075$$

$$= \underline{15.1\ N}$$

~~2056)~~

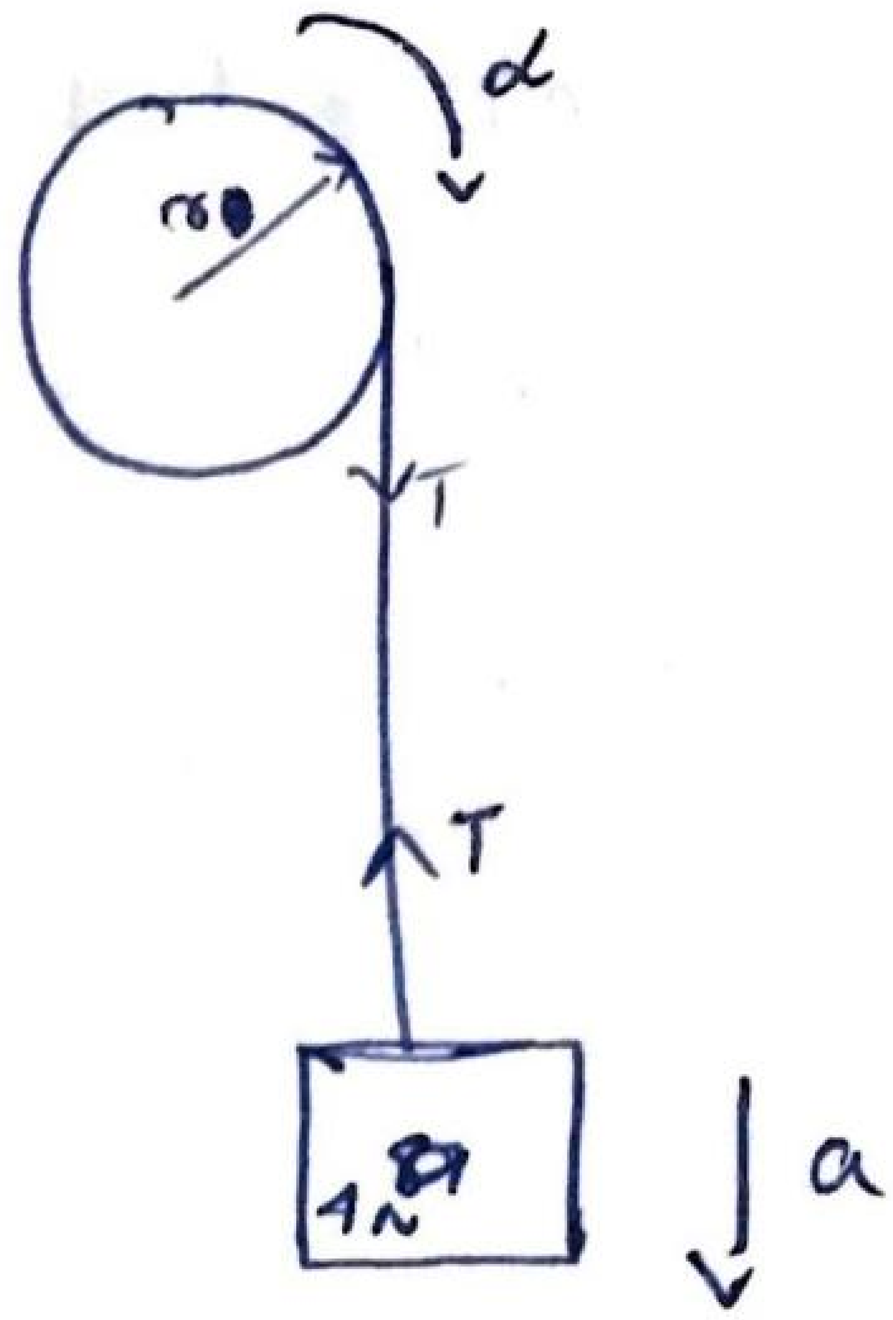
20 a) pully → solid disc

(i) Moment of inertia $= \frac{1}{2} m r^2$

$$I = \frac{1}{2}\left(\frac{w}{g}\right) r^2$$

$$= \frac{1}{2} \times \left(\frac{48}{9.8}\right) \times 0.25^2$$

$$= 0.153 \, kg/m^2$$



(i) $\tau = I\alpha$

$$I\alpha = T \times r \quad \text{— (1)}$$

$$a = r\alpha$$

$$\alpha = \frac{a}{r}$$

so, $I \times \frac{a}{r} = Tr$

$$0.153 \times \frac{a}{0.25} = 0.25 T$$

$$T = 2.448a$$

By D-Alembert's principle,

$$4 - T = ma$$

$$4 - T = \left(\frac{w}{g}\right) a$$

Sub $T = 2.448a$

$$4 - 2.448a = \left(\frac{4}{9.8}\right) a$$

$$4 - 2.448a = 0.41a$$

$$2.858a = 4$$

$$a = \frac{4}{2.858} = \underline{\underline{0.452 \, m/s^2}}$$

(ii) $T = 2.448a$

$$= 2.448 \times 0.452$$

$$= \underline{\underline{1.105 \, N}}$$

20

b)

(i) $\theta = \left(\frac{\omega_{final} + \omega_{initial}}{2}\right) t$

$$40 = \left(\frac{\omega_{final} + 30}{2}\right) \times \frac{50}{60}$$

$$\frac{\omega_{final} + 30}{2} = 48$$

$$\omega_{final} + 30 = 96$$

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$$\omega_{final} = 66 \text{ r.p.m}$$

(ii)

$$\omega_{final} = \omega_{initial} + \alpha t$$

$$\alpha = \frac{\omega_{final} - \omega_{inital}}{t}$$

$$= \frac{66 - 30}{0.833}$$

$$= 43.37$$

now, we have to find time to reach. 80 r.p.m

$$\alpha = \frac{\omega_{final} - \omega_{inital}}{t}$$

$$43.37 = \frac{80 - 30}{t}$$

$$t = \frac{80 - 30}{43.37}$$

$$= 1.153 \text{ min}$$