Reg. No. : | | | | | | | | | | | |

Question Paper Code : 71945

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Second Semester

Civil Engineering

GE 6253 – ENGINEERING MECHANICS

(Common to Mechanical Engineering (Sandwich), Aeronautical Engineering, Agriculture Engineering, Automobile Engineering, Civil Engineering, Environmental Engineering, Geoinformatics Engineering, Industrial Engineering, Industrial Engineering and Management, Manufacturing Engineering, Marine Engineering, Materials Science and Engineering, Mechanical Engineering , Mechanical and Automation Engineering, Mechatronics Engineering, Petrochemical Engineering, Production Engineering, Robotics and Automation Engineering, Chemical Engineering, Chemical and Electrochemical Engineering, Fashion Technology, Food Technology, Handloom and Textile Technology, Petrochemical Technology, Petroleum Engineering, Pharmaceutical Technology, Plastic Technology, Polymer Technology, Textile Chemistry, Textile Technology, Textile Technology(Fashion Technology))

(Regulations 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. State the principle of transmissibility.
2. Find the resultant and direction of Force $\vec{F} = 3i - 4j$.
3. Differentiate between moment and couple.
4. A uniform ladder of weight 'W' leans against a vertical wall. Assuming the contact surfaces as rough, draw the free body diagram of the ladder with necessary assumptions.
5. Differentiate between center of gravity and centroid.
6. State parallel axis theorem as applied to area Moment of Inertia.
7. The displacement of a particle is given by $S = 3t^2 + 2t$ meters. Where 't' is in seconds? Find the velocity and acceleration when t = 10 seconds.
8. State the principle of work-energy.

9. What is dry friction?

10. What is general plane motion? Give one example.

PART B — (5 × 16 = 80 marks)

11. (a) Two cylinders C, F of diameter 60mm and 30mm. weighing 160 N and 40 N respectively are placed as shown in Fig. 11(a). Assuming all the contact surfaces to be smooth, find the reactions at A, B and C.

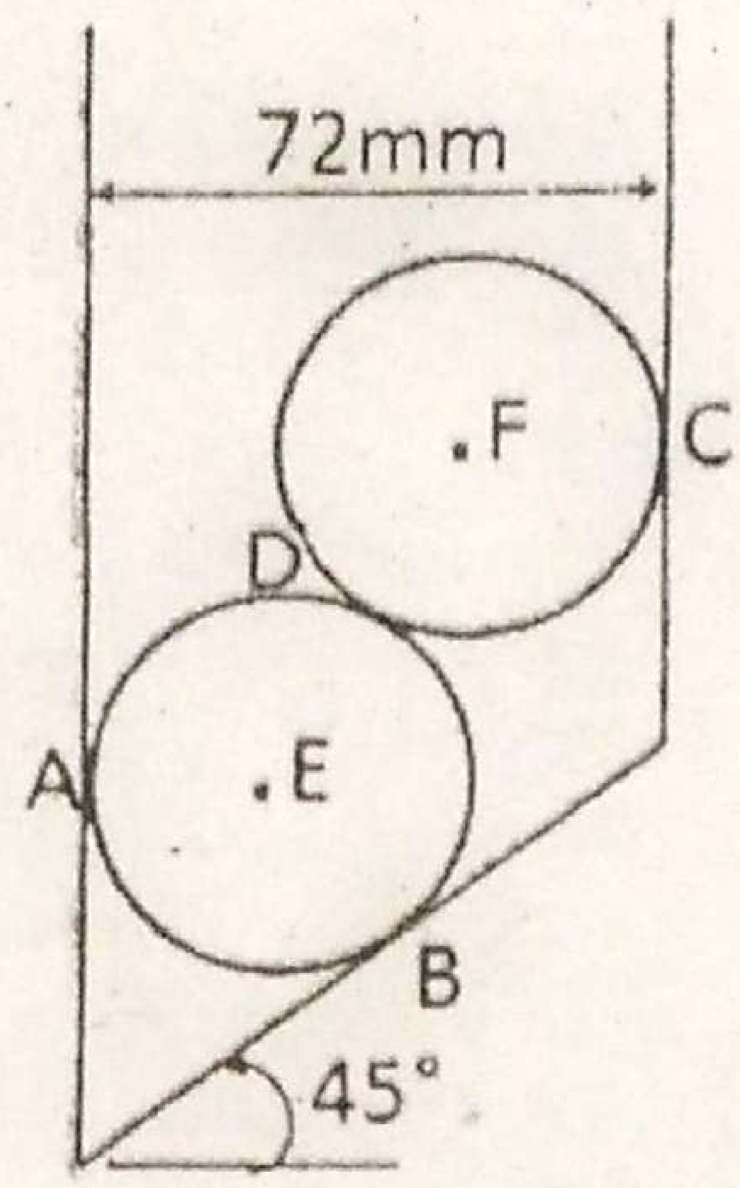


Fig. 11(a)

Or

(b) Forces 32 kN, 24 kN, 24 kN and 120 kN are concurrent at origin (0,0,0) and are respectively directed through the points whose coordinates are A(2, 1, 6). B(4, –2, 5), C(–3, –2, 1) and D(5, 1, –2). Determine resultant of the system.

12. (a) Four tug boats are used to bring a large ship to its pier. Each tug boat exerts a 5000N force in the direction as shown in Fig. 12(a). Determine the equivalent force-couple system at point 'O', and the point on hull where a single more powerful tugboat should push to produce the same effect as the original four tugboats.

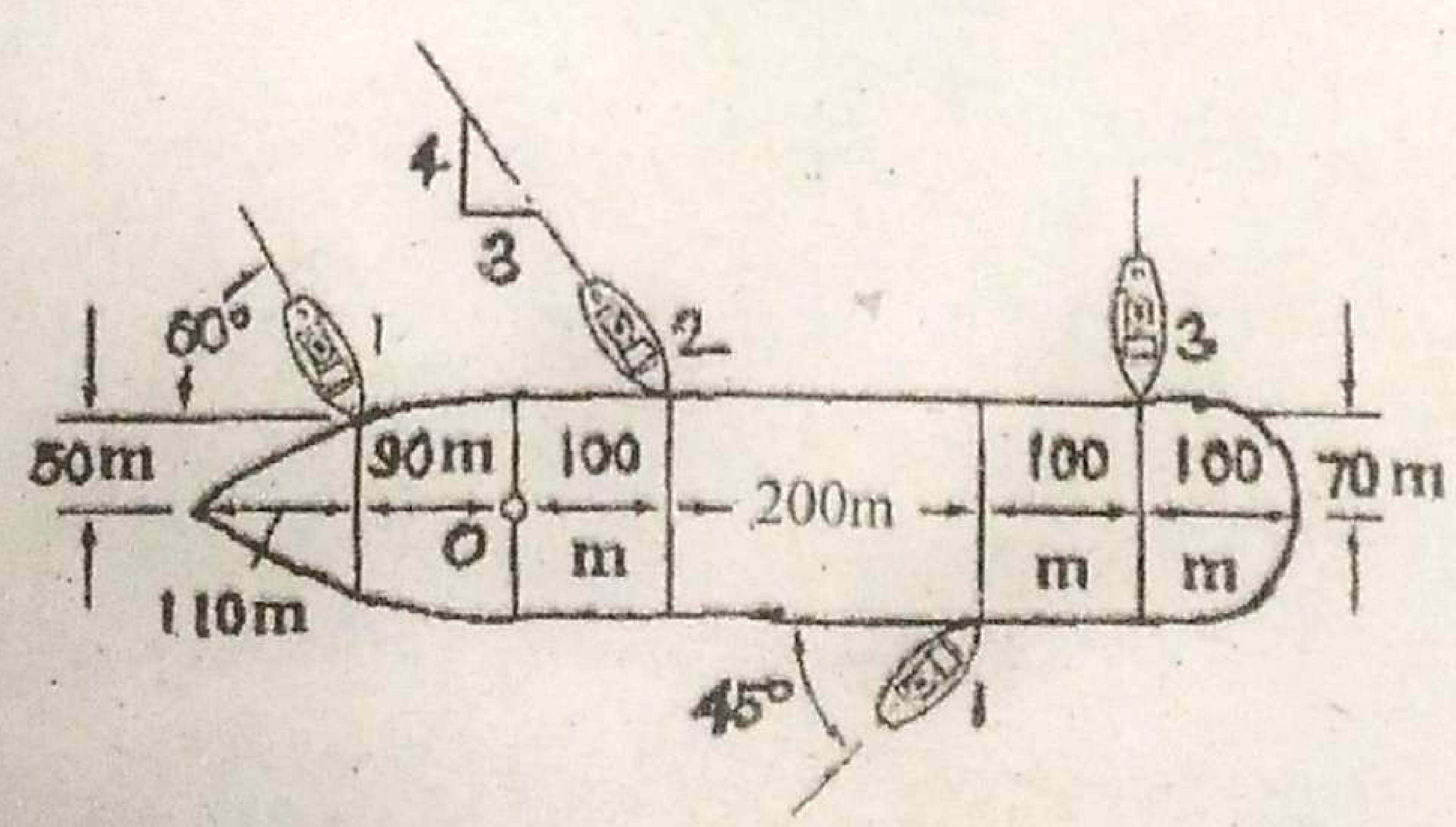


Fig. 12(a)

Or

(b) A light bar AD is suspended from a cable BE and supports a 50 kg block at C as shown in Fig. 12(b). The ends A and D of the bar are in contact with frictionless vertical walls. Determine the tension in cable BE and the reactions at A and D.

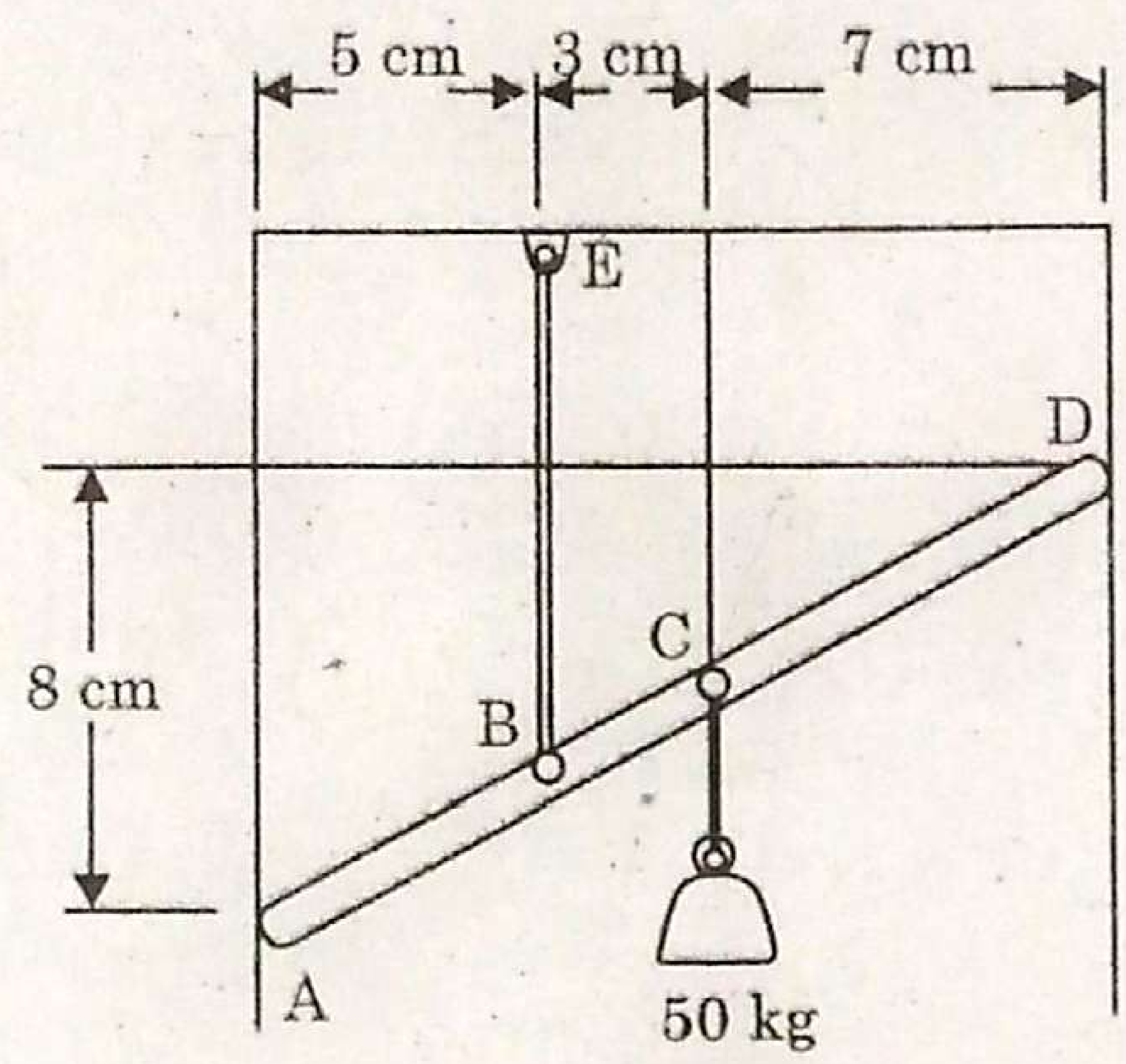


Fig. 12(b)

13. (a) Determine the location of centroid for the right angle triangle from the first principles and find the volume of cone using Pappus-Guldinus theorem.

Or

(b) Calculate the moment of inertia of the section shown in Fig. 13(b) about "x" and "y" axes through the centroid.

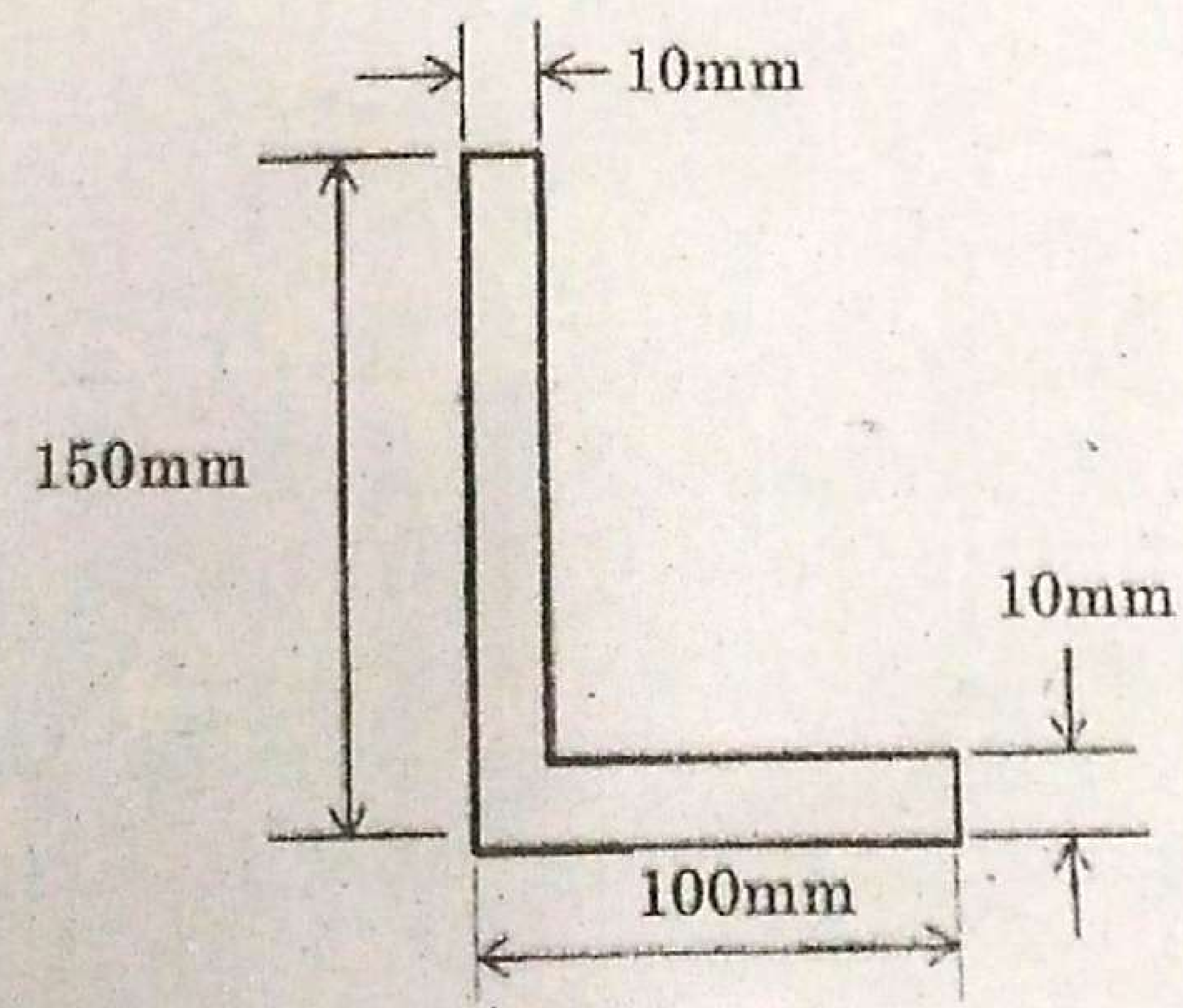


Fig. 13(b)

14. (a) A body moving with uniform acceleration is observed to travel 33 m in 8^{th} second and 53 m in 13^{th} second of its travel. Calculate the velocity at start and uniform acceleration.

Or

(b) Two blocks 'A' and 'B' of masses $m_A = 280$ kg and $m_B = 420$ kg are joined by an inextensible cable as shown in Fig. 4(b). Assume that the pulley is frictionless and $\mu = 0.30$ between block 'A' and the surface. The system is initially at rest. Determine (i) acceleration of block A: (ii) velocity after it has moved 3.5 m; and (iii) velocity after 1.5 seconds.

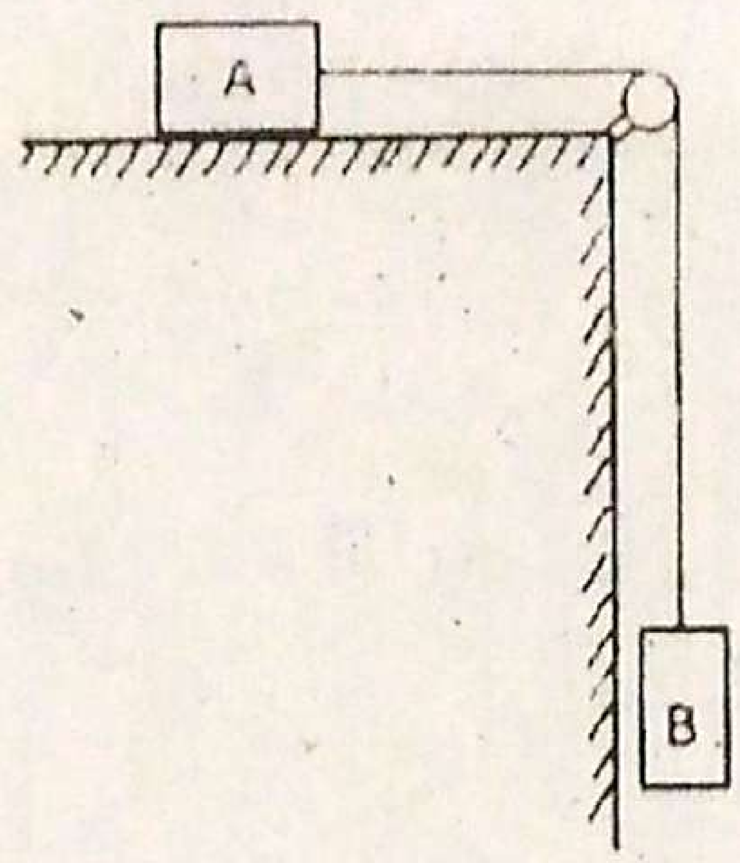


Fig. 14 (b)

15. (a) A 100 N force acts on a 300N block placed on an inclined plane as shown in Fig. 15(a). The coefficients of friction between the block and the plane are $\mu_s = 0.25$ and $\mu_k = 0.20$. Determine whether the block is in equilibrium, and find the value of the friction force.

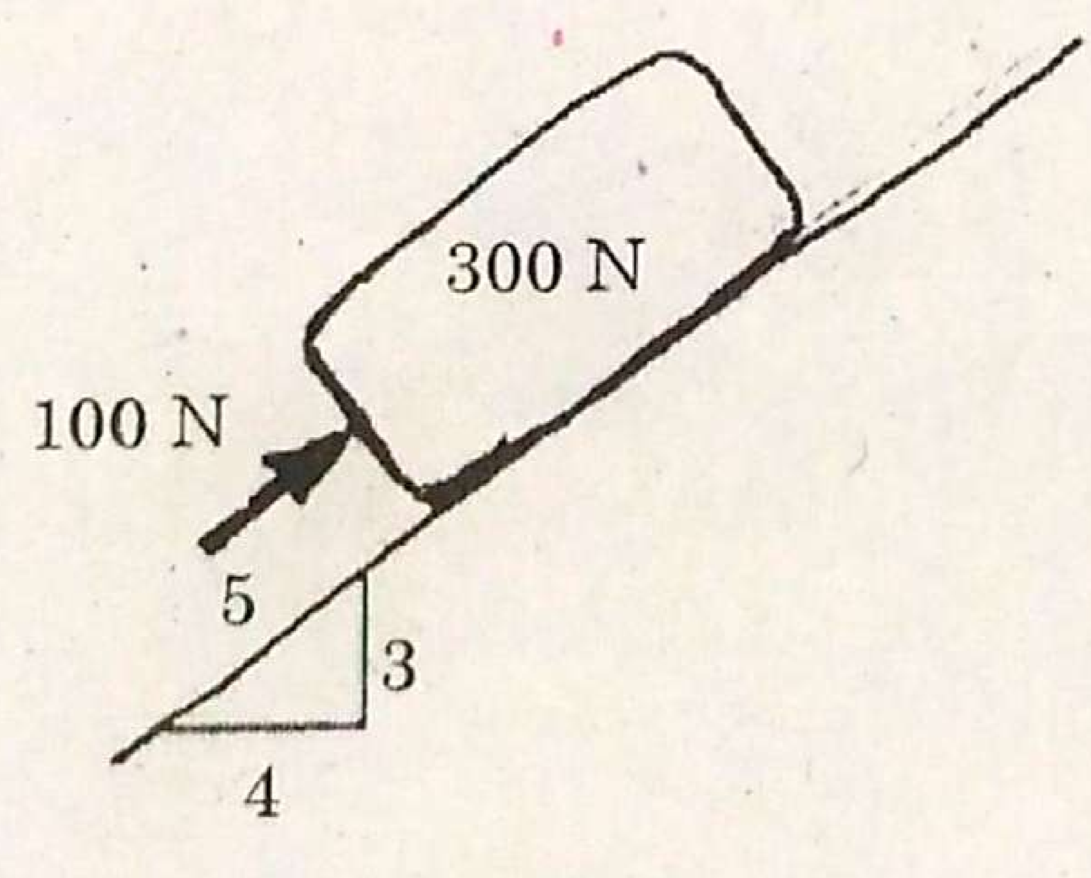


Fig. 15 (a)

Or

(b) A wheel is attached to the shaft of an electric motor of rated speed of 2000 rpm. When the power is switched on, the wheel attains the rated speed in 10 seconds and when the power is switched off, the unit comes to rest in 100 seconds. Assume uniformly accelerated motion and determine the number of revolutions the unit turns (i) to attain the rated speed and (ii) to come to rest.

GE6253 - Engineering Mechanics

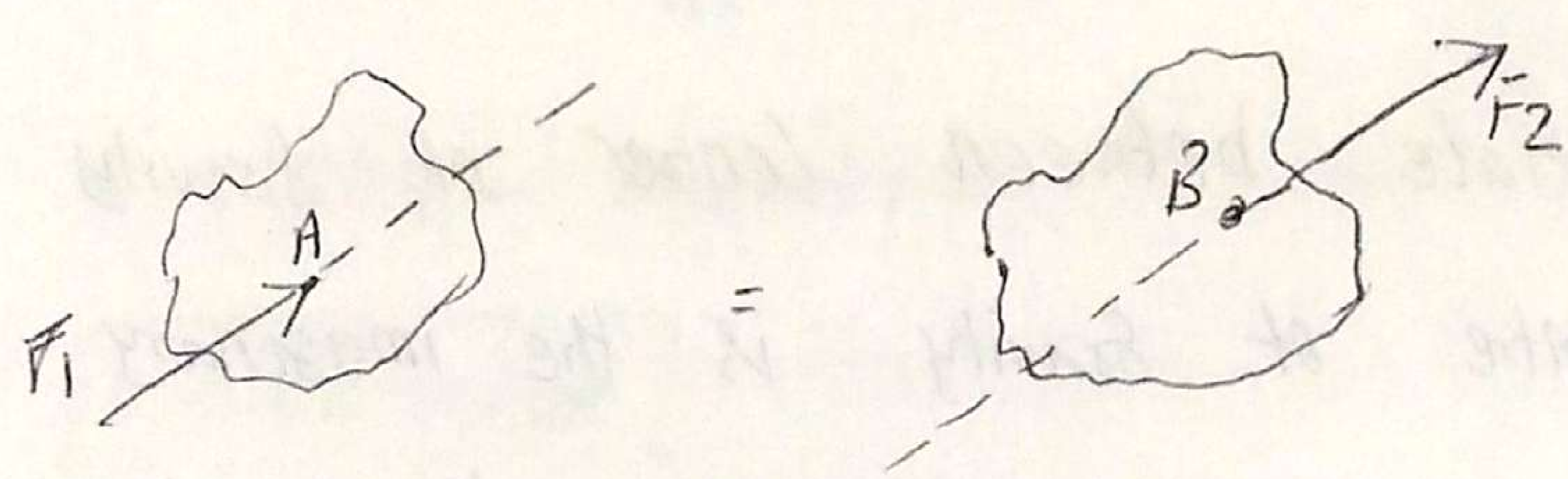
Apr / May - 2017.

(Regulations - 2013)

Part - A

1. Principle of Transmissibility:

A force can be replaced by another force acting at a different point, provided that the line of action of these two forces are same.



2. Find the Resultant & direction of force $\vec{F} = 3i - 4j$

$$\vec{F} = 3i - 4j$$

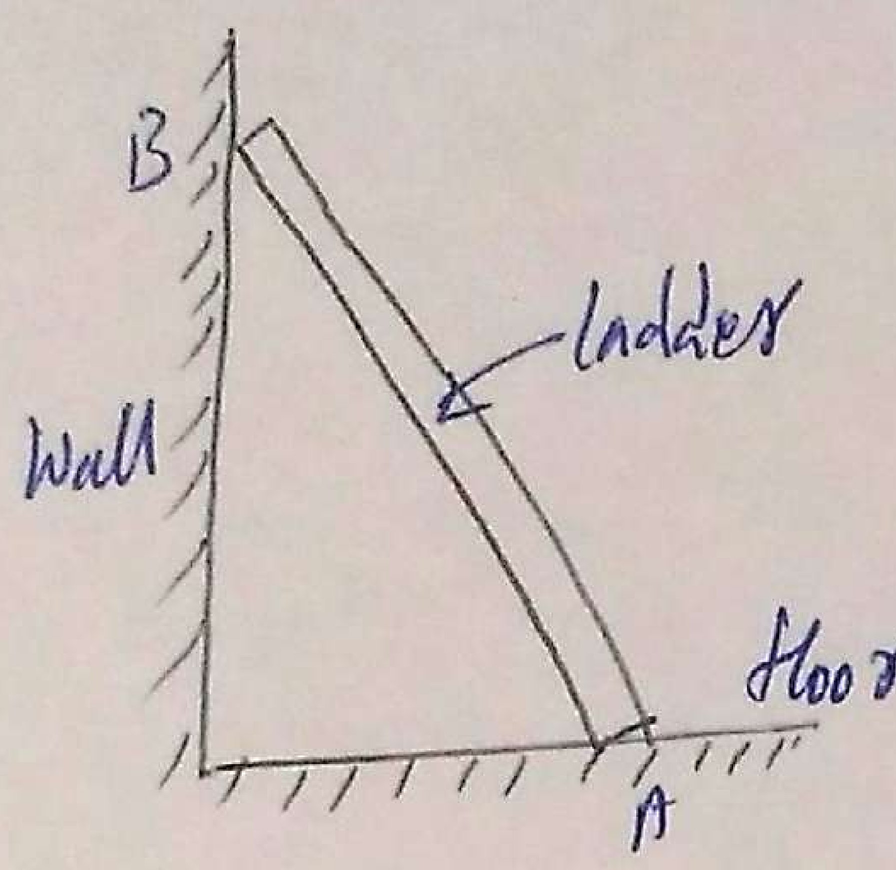
$$|F| = \sqrt{3^2 + (4)^2} = 5N$$

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(4/3\right) = 53.13^\circ$$

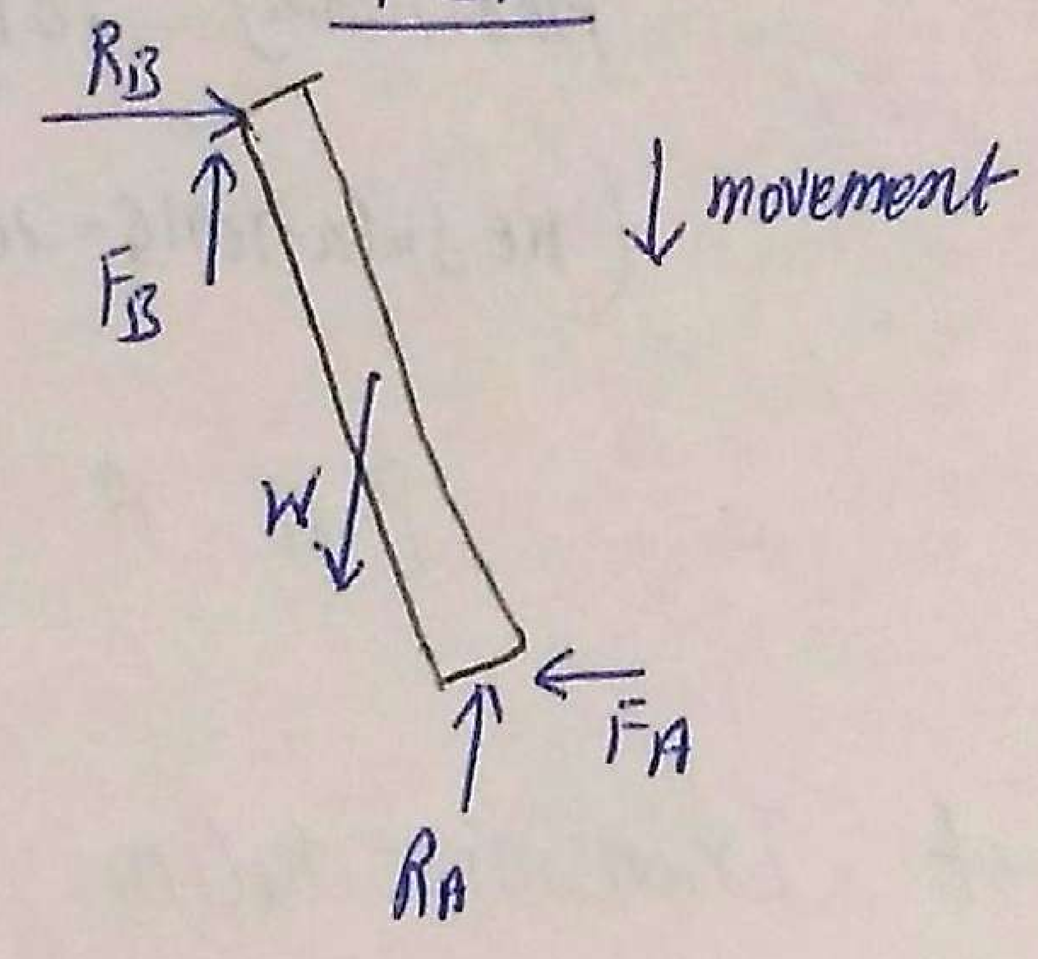
3. Differentiate between moment and couple.

Moment is having only one force, where as couple has two forces acting parallel but opposite in direction kept between a distance. Moment has a resultant force but couple has no Resultant force.

④ Free body diasram of the ladder



FBD



R_A & R_B - Reaction force

W - self-weight

F_A & F_B - frictional force.

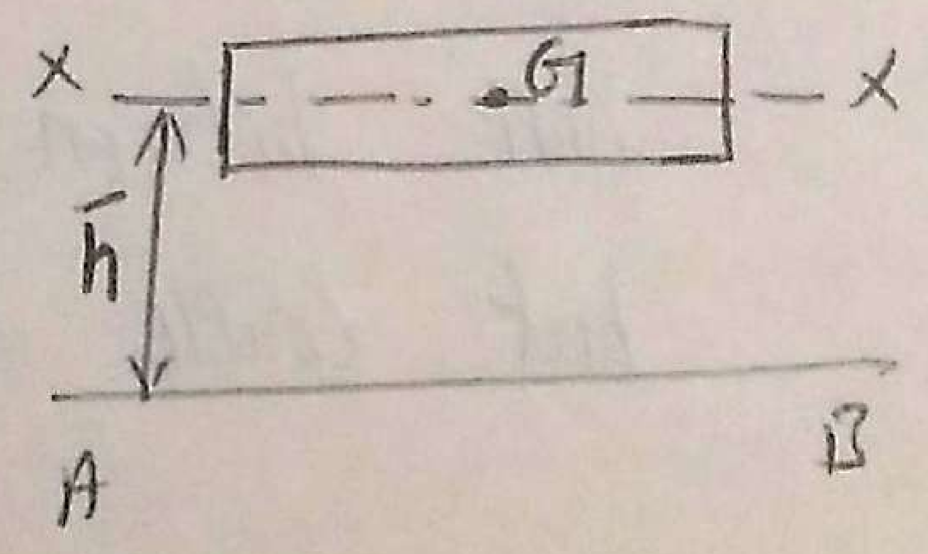
5. Differentiate between Center of Gravity & Centroid.

Centre of Gravity is the imaginary point at which the weight of the object is assumed to be concentrated.

Centroid is the Geometric concept, in which the Area is assumed to be concentrated at a point.

6. Parallel axis theorem :

Moment of inertia of a lamina about any axis in the plane of lamina is equal to the sum of the M.O.I about a parallel centroidal axis in the plane of lamina and the product of the area of the lamina and square of the distance between the two axes".



$$\boxed{I_{AB} = I_{xx} + A\bar{h}^2}$$

7. Given data:

$S = 3t^2 + 2t$

$t = 10$ sec.

To Find:

$v = ?$

$a = ?$

Solution:

$S = 3t^2 + 2t$

$v = ds/dt = \frac{d}{dt}(3t^2 + 2t)$

$v = 6t + 2 = 6(10) + 2$

$\boxed{v = 62 \text{ m/sec}}$

$a = \frac{dv}{dt} = \frac{d}{dt}(6t + 2)$

$\boxed{a_{10} = 6 \text{ m/s}^2}$

8. Principle of work - energy:

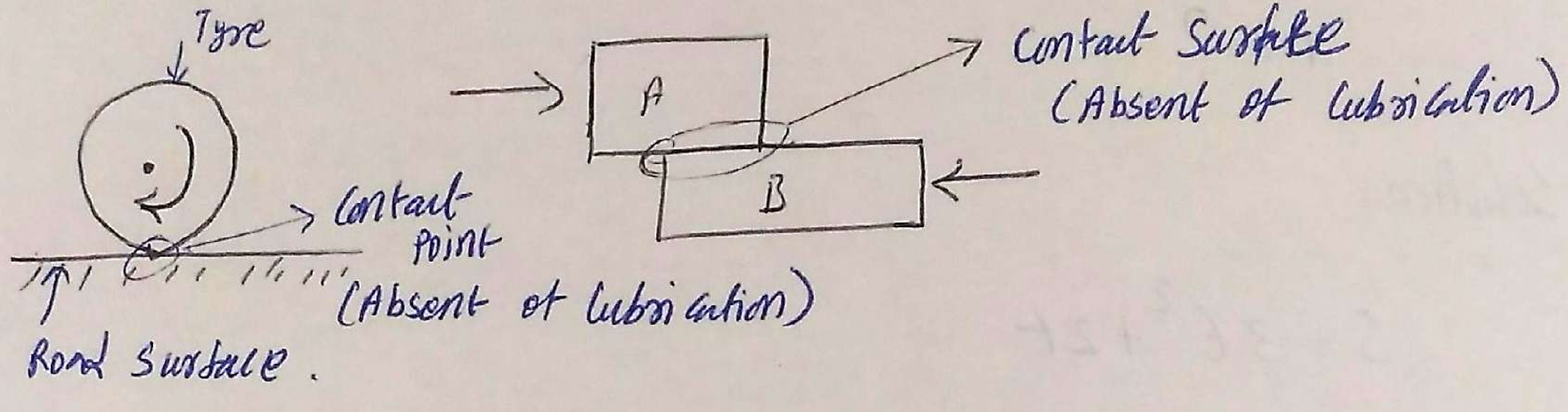
It states that the work done by all forces acting on a particles equals the change in the kinetic energy of the particle.

Work done = Final kinetic energy - Initial kinetic energy.

$\Sigma F_x \times S = \frac{W}{2g}(v^2 - u^2)$

9. Dry friction.

It is the frictional resistance offered by two surfaces in contact when they have relative movement between them. The contact surfaces will not have any fluids between them.



10. General plane motion:

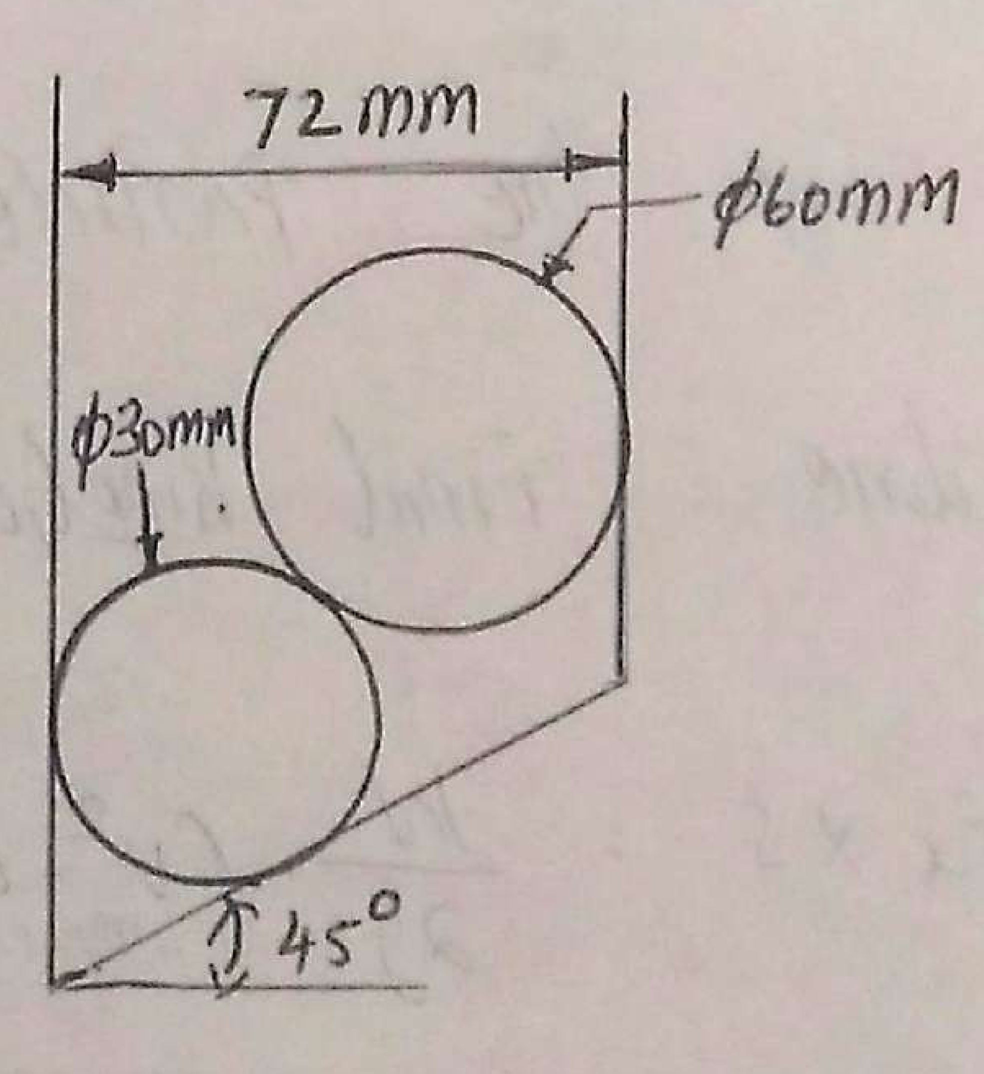
A plane of motion which is neither pure translation nor a pure rotation is known as a general plane motion.

$$\boxed{\text{General plane motion} = \text{Translation} + \text{Rotation}}$$

Ex: Connecting road, Rolling wheel.

Part - B

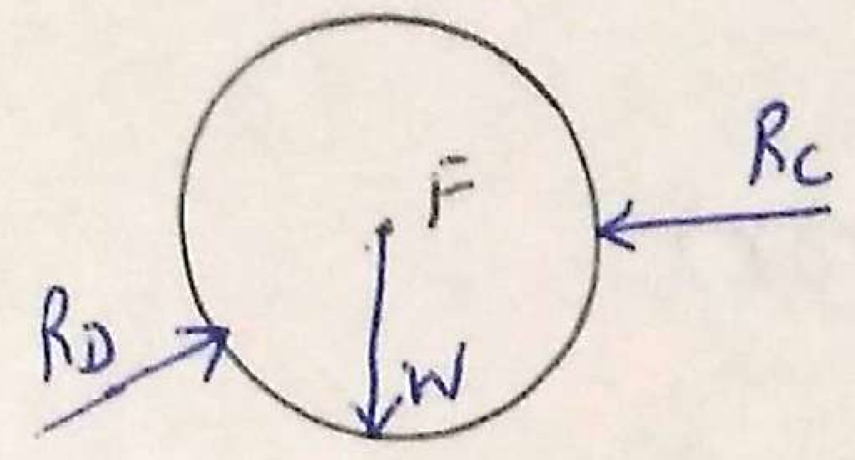
11) a) Given data:

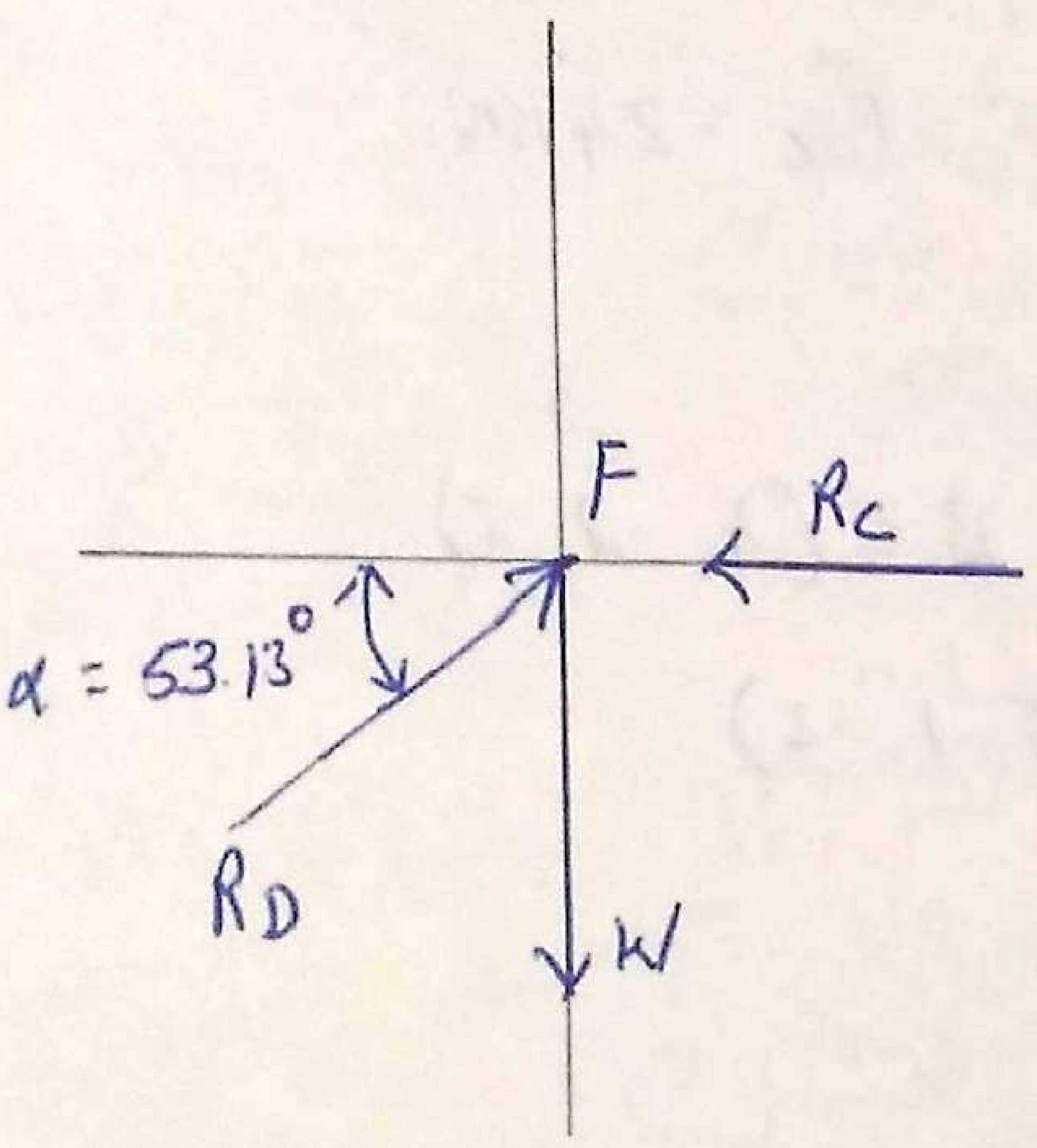


$$\cos\alpha = \frac{27}{45}$$

$$\alpha = 53.13^\circ$$

FBD for Ball 'F'





$\Sigma H = 0$

$$\boxed{R_D \cos 53.13^\circ - R_C = 0} \quad (i)$$

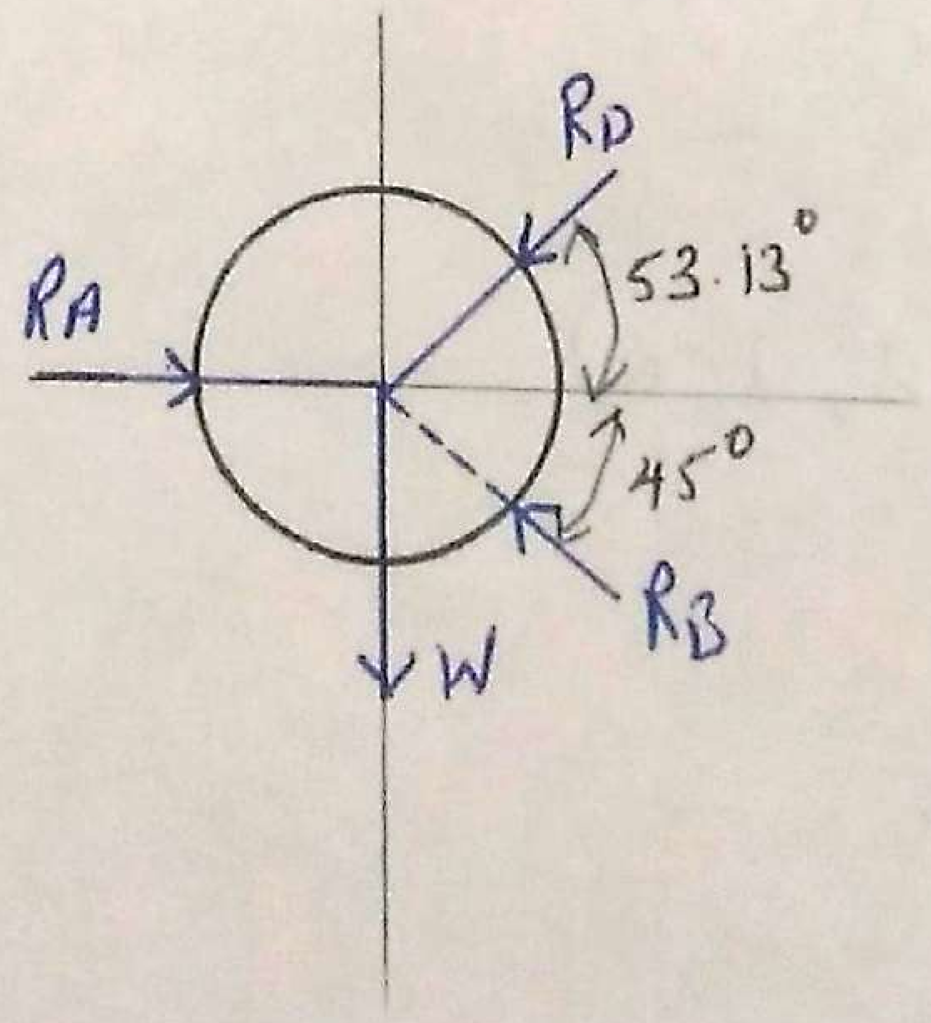
$\Sigma V = 0$

$$\boxed{W - R_D \cos 53.13^\circ = 0}$$

$$R_D = \frac{40}{\cos 53.13^\circ}$$

$R_D = 50N$
$R_C = 30N$

FBD for Ball 'E':



$\Sigma H = 0$

$$\boxed{R_A - R_D \cos 53.13^\circ - R_B \cos 45^\circ = 0} \quad (i)$$

$\Sigma V = 0$

$$\boxed{W + 50 \sin 53.13^\circ - R_B \sin 45^\circ = 0}$$

$$R_B = \left(\frac{160 + 50 \sin 53.13^\circ}{\sin 45^\circ}\right)$$

$R_B = 282.8N$	$R_A = 230N$

Result:

$R_A = 230 N$

$R_B = 282.2 N$

$R_C = 30 N$

$R_D = 50 N$

(or)

11) b) Given data:

Force: $F_{OA} = 32 kN$; $F_{OB} = 24 kN$: $F_{OC} = 24 kN$:

and $F_{OD} = 120 kN$.

Position: $O = (0,0,0)$: $A = (2,1,6)$, $B = (4,-2,5)$

$C = (-3,-2,1)$ & $D = (5,1,-2)$

To Find:

$\vec{R} = ?$

Solution:

$$\vec{F}_{OA} = F_{OA} \vec{\lambda}_{OA}$$

$$\lambda_{OA} = \frac{\vec{OA}}{OA}$$

$$\vec{OA} = (0,0,0) - (2,1,6)$$

$$\vec{OA} = 2i + j + 6k$$

$$OA = \sqrt{(2)^2 + (1)^2 + (6)^2}$$

$$OA = 6.403 \ m$$

$$\vec{F_{OA}} = 32\left[\frac{2i+j+6k}{6.403}\right]$$

$$\boxed{\vec{F_{OA}} = 9.984i + 4.992j + 29.984k.}$$

$$\vec{F_{OB}} = F_{OB}.\lambda_{OB}$$

$$\lambda_{OB} = \frac{\vec{OB}}{OB} = \frac{(0-4)i,(0-(-2))j,(0-5)k}{\sqrt{4^2+(-2)^2+(5)^2}}$$

$$\lambda_{OB} = \frac{4i+2j+5k}{6.708}$$

$$\vec{F_{OB}} = 24\left[\frac{4i \mp 2j+5k}{6.708}\right]$$

$$\boxed{\vec{F_{OB}} = 14.304i - 7.152j + 17.880k}$$

$$\vec{F_{OC}} = F_{OC}.\lambda_{OC}$$

$$\lambda_{OC} = \frac{\vec{OC}}{OC} = \frac{(-3-0)i,(-2-0)j,(1-0)k}{\sqrt{3^2+2^2+1^2}}$$

$$\lambda_{OC} = \frac{-3i-2j+k}{3.742}$$

$$\lambda_{OC} = -0.802i + 0.535j + 0.267k.$$

$$\vec{F_{OC}} = 24(-0.802i - 0.535j + 0.267k)$$

$$\boxed{\vec{F_{OC}} = -19.248i - 12.84j + 6.408k.}$$

$$\vec{F_{OD}} = F_{OD}.\lambda_{OD}$$

$$\lambda_{OD} = \frac{\vec{OD}}{OD} = \frac{(5-0)i,(1-0)j,(-2-0)k}{\sqrt{5^2+1^2+2^2}}$$

$$\lambda_{OD} = 0.918\,i + 0.183\,j - 0.365\,k$$

$$\vec{F}_{OD} = F_{OD} \cdot \lambda_{OD}$$

$$= 120 \cdot [0.918\,i + 0.183\,j - 0.365\,k]$$

$$\boxed{\vec{F}_{OD} = 109.56\,i + 21.96\,j - 43.8\,k.}$$

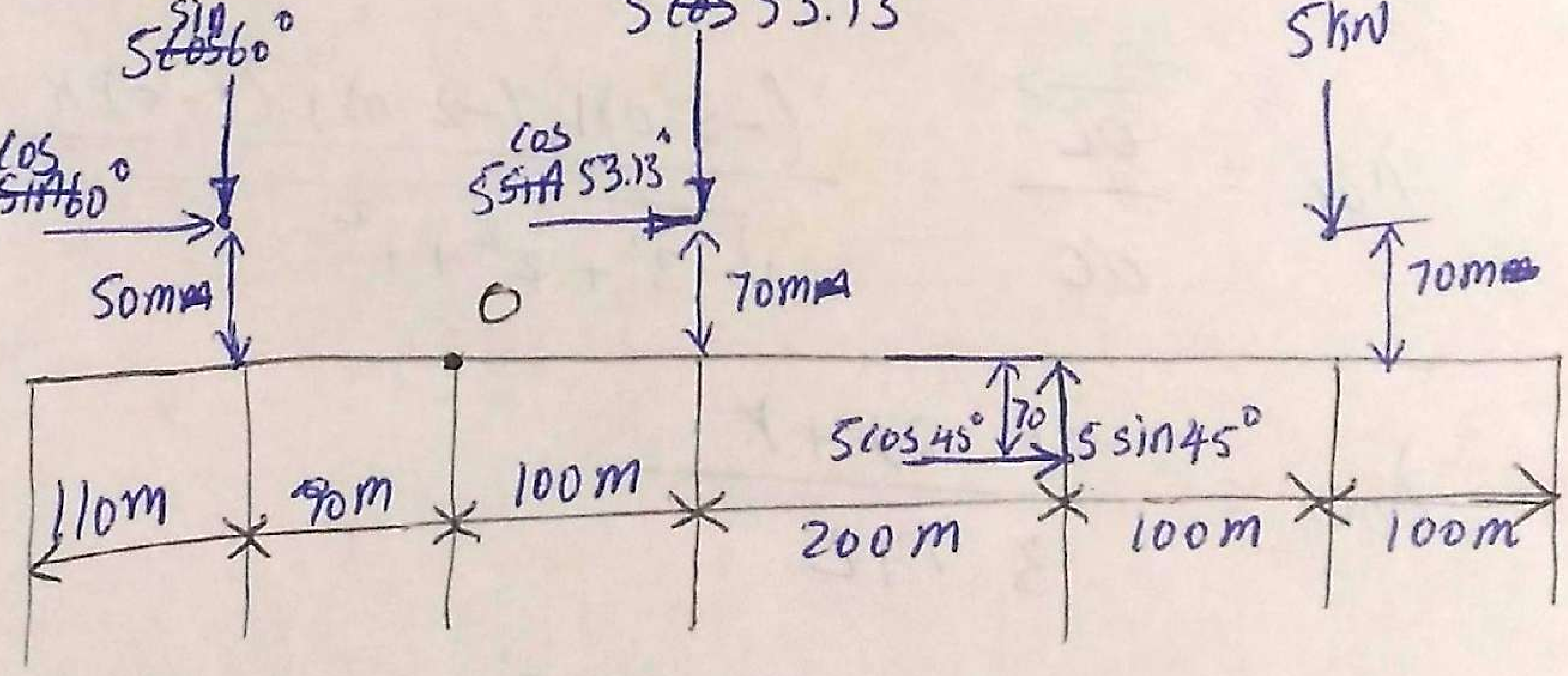
$$\vec{R} = \vec{F}_{OA} + \vec{F}_{OB} + \vec{F}_{OC} + \vec{F}_{OD}$$

$$\vec{R} = 114.6\,i + 6.96\,j + 10.472\,k.$$

$$R = \sqrt{(114.6)^2 + (6.96)^2 + (10.472)^2}$$

$$\boxed{R = 115.28\ kN.}$$

12) a) Given data:



To Find:

Force Couple system at Point 'O'.

Solution: $\tan^{-1}(4/3) = 53.13°$

$$\Sigma_H = 5\cos 60° + 5\cos 53.13 + 5\cos 45°$$

$$\boxed{\Sigma_H = 9.034\ kN}$$

$$\Sigma V = 5 \sin 45^\circ - 5 \sin 60^\circ - 5 \sin 53.13 - 5$$

$$\boxed{\Sigma H = -9.79 \text{ kN}}$$

$$R = \sqrt{\Sigma H^2 + \Sigma V^2}$$

$$= \sqrt{9.034^2 + (-9.79)^2}$$

$$\boxed{R = 13.32 \text{ kN}}$$

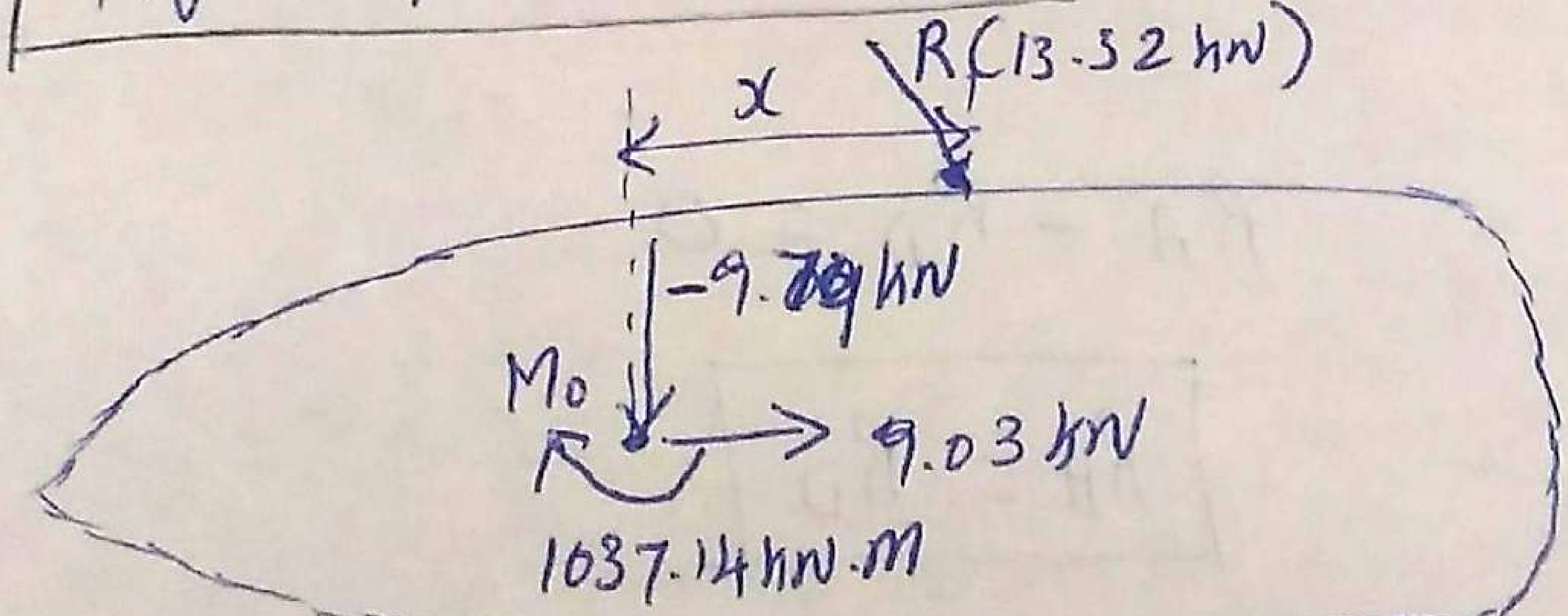
$$\alpha = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{9.79}{9.034}\right)$$

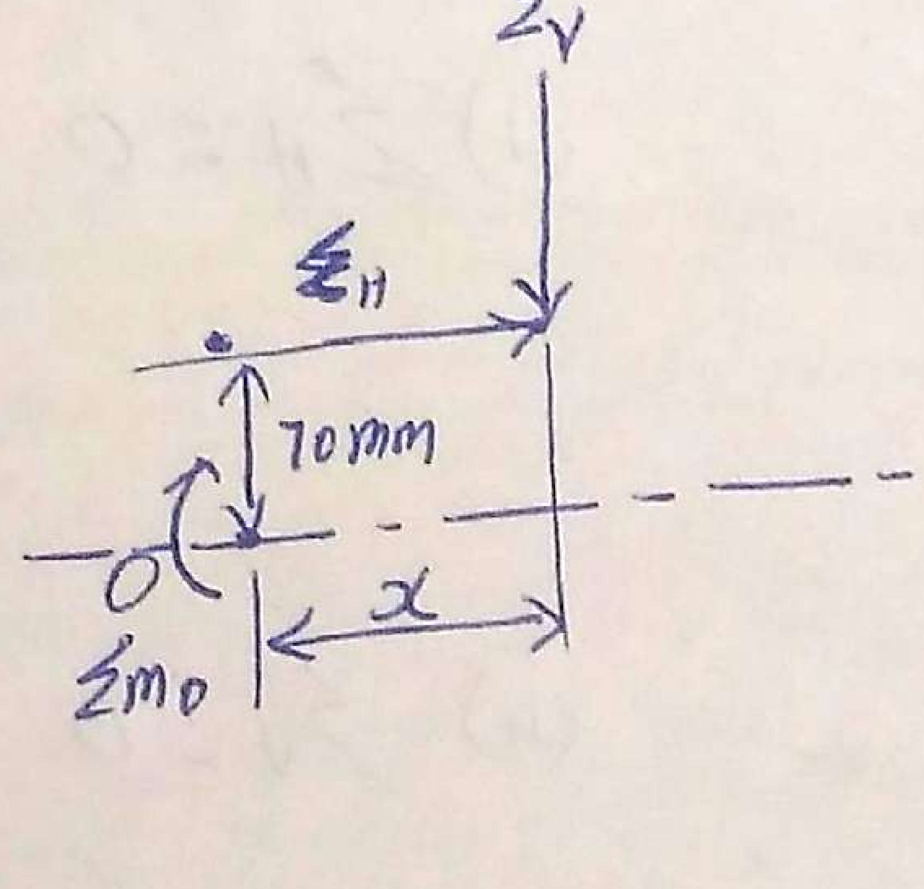
$$\boxed{\alpha = 47.30^\circ}$$

Taking moment about 'O'. (M_O)

$$M_O = (5 \cos 60^\circ \times 50) - (5 \sin 60^\circ \times 90) + (5 \cos 53.13 \times 70)$$
$$+ (5 \sin 53.13 \times 100) - (5 \cos 45^\circ \times 70) - (5 \sin 45^\circ \times 300)$$
$$+ (5 \times 400)$$

$$\boxed{M_O = 1037.14 \text{ kN.m}}$$



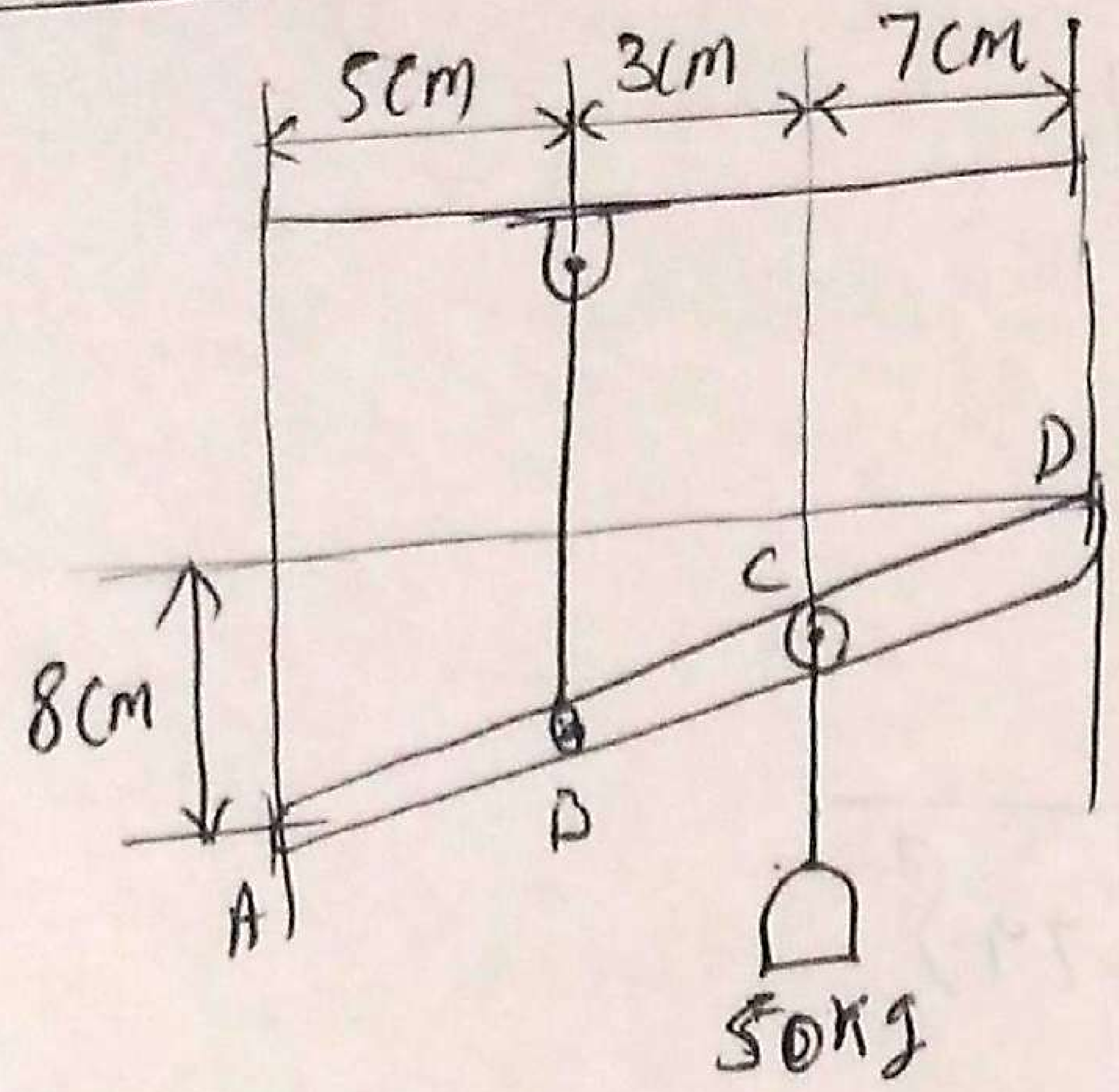


$$\Sigma M_O = (\Sigma V \times x) + (\Sigma H \times 70)$$

$$1037.14 = (+9.79 \times x) + (9.034 \times 70)$$

$$\boxed{x = 41.34 \text{ m}}$$

12) b) Given data:



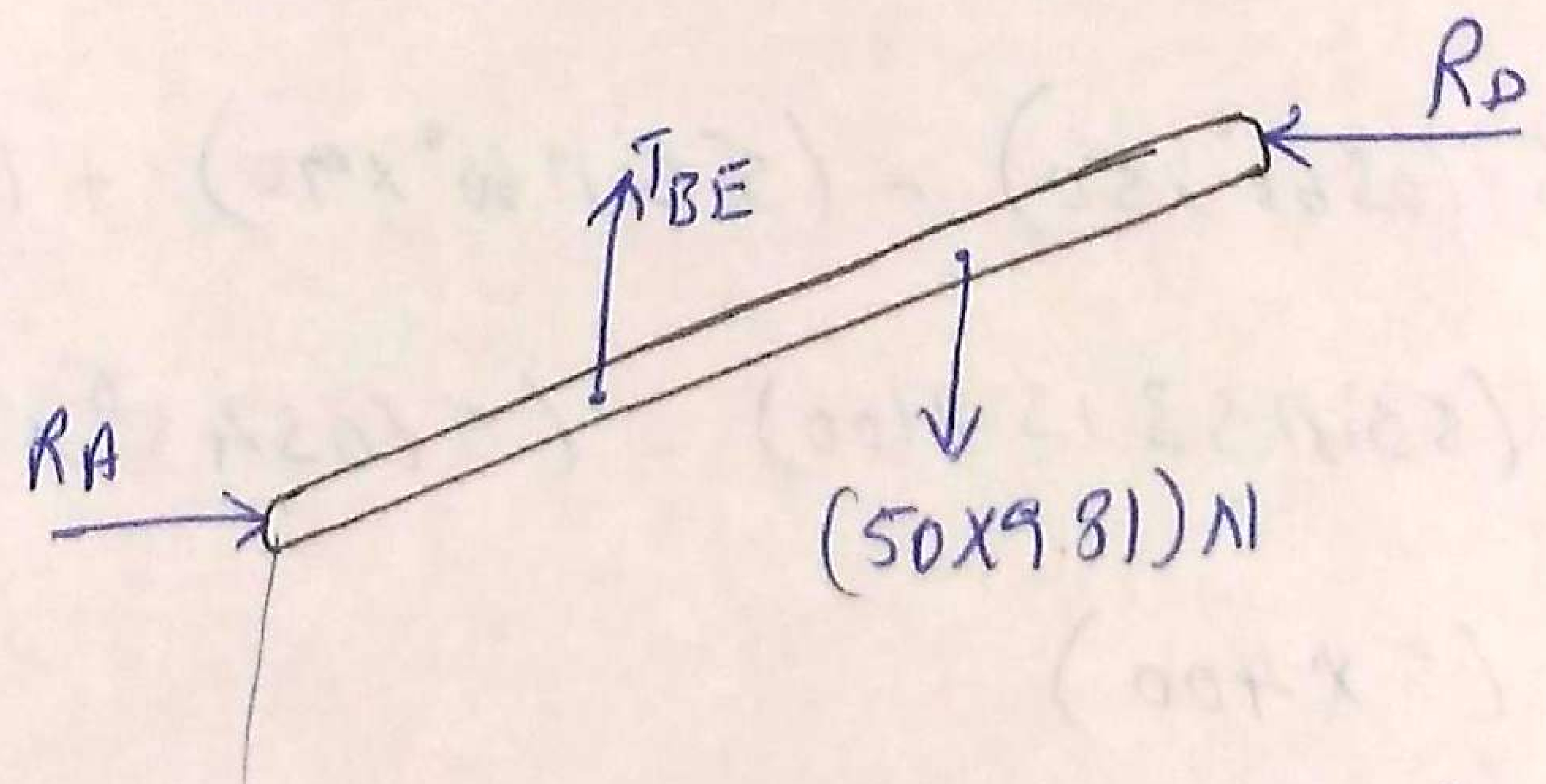
To Find:

$T_{BE} = ?$

R_A & $R_D = ?$

Solution:

FBD for the bar



Applying Equilibrium $(R=0)$ $(\because \Sigma H = 0$ & $\Sigma V = 0)$
$\Sigma M = 0$

i) $\Sigma H = 0 \Rightarrow R_A - R_D = 0$

$$\boxed{R_A = R_D}$$

ii) $\Sigma V = 0 \Rightarrow$

$T_{BE} - (50 \times 9.81) = 0$

$$\boxed{T_{BE} = 490.5 \text{ kN}}$$

(iii) $\Sigma M_A = 0$

$$-(490.5 \times 5) + (490.5 \times 8) - (R_D \times 8) = 0$$

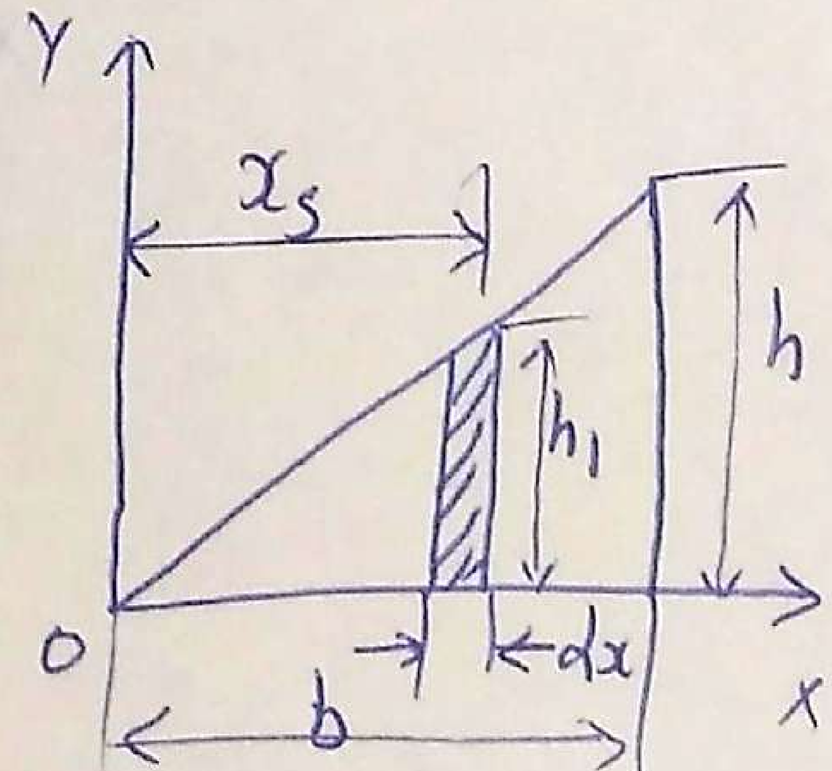
$R_D = 183.93$ N
$R_A = 183.93$ N.

13) a) i) Locate the centroid for the right angle triangle.

ii) Find the volume of cone using Pappus-Guldins theorem.

Locate the centroid

Consider a vertical rectangular strip of thickness dx & height (h_1) at a distance of x from OY axis as shown in fig.



Area of strip, $dA = dx \cdot h_1$

Area of triangle, $A = \int_0^b dA = \int_0^b dx \cdot h_1$

From similar triangles,

$$\frac{h}{b} = \frac{h_1}{x+dx}$$ but dx is very small.

$$\frac{h}{b} = \frac{h_1}{x} \Rightarrow h_1 = \frac{h}{b}x$$

$\therefore$ Area of triangle $A = \int_0^b \left(\frac{h}{b}x\right) dx$

$$= \frac{h}{b}\int_0^b x\,dx$$

$$= \frac{h}{b}\left[\frac{x^2}{2}\right]_0^b = \frac{h}{b}\left[\frac{b^2}{2}\right]$$

$$= \frac{hb}{2}$$

Using the result $= (\bar{x}) = \int \frac{x_s\,dA}{A}$

here, $x_s = x + \frac{dx}{2}$: (but dx is very small)

$\therefore x_s = x$

$$\bar{x} = \int \frac{x\,dA}{A} = \int_0^b \frac{x\,(dx \cdot h_1)}{A}$$

$$= \frac{1}{A}\int_0^b x \cdot dx\left(\frac{h}{b}x\right)$$

$$= \frac{2}{bh} \times \frac{h}{b}\int_0^b x^2\,dx.$$

$$= \frac{2}{b^2}\left[\frac{x^3}{3}\right]_0^b = \frac{2}{b^2}\left[\frac{b^3}{3}\right]$$

$$\boxed{\bar{x} = \frac{2b}{3}}$$

To Find $\bar{y}$:

$$dA = dx \cdot h_1 \quad \& \quad A = \frac{hb}{2}$$

Centroidal distance of the strip from OX axis $\Big\} \; y_s = \frac{h_1}{2} = \frac{1}{2}\left[\frac{h}{b} x\right]$

$$\bar{y} = \int \frac{y_s \, dA}{A} = \frac{1}{A} \int_0^b \left[\left(\frac{h}{2b} x\right)(dx \cdot h_1)\right]$$

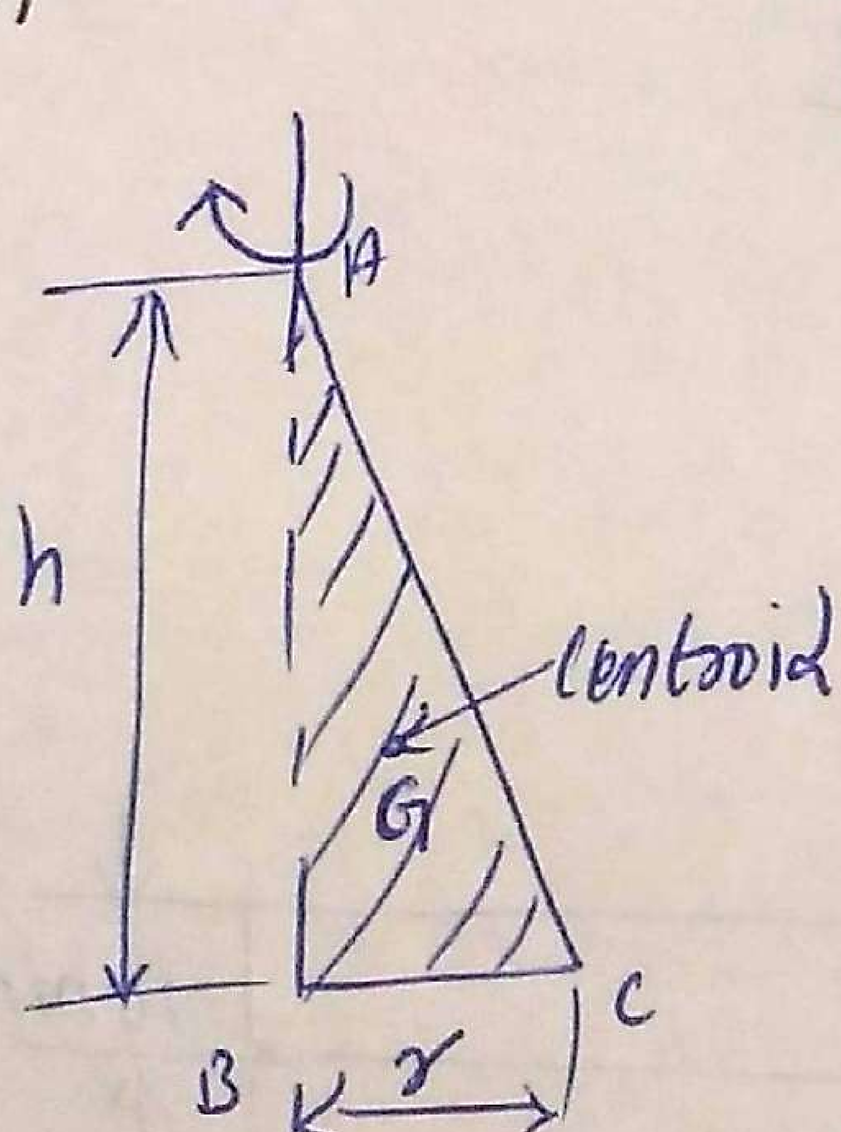
$$= \frac{1}{A} \int_0^b \left(\frac{hx}{2b}\right)\left(\frac{h}{b} x \, dx\right)$$

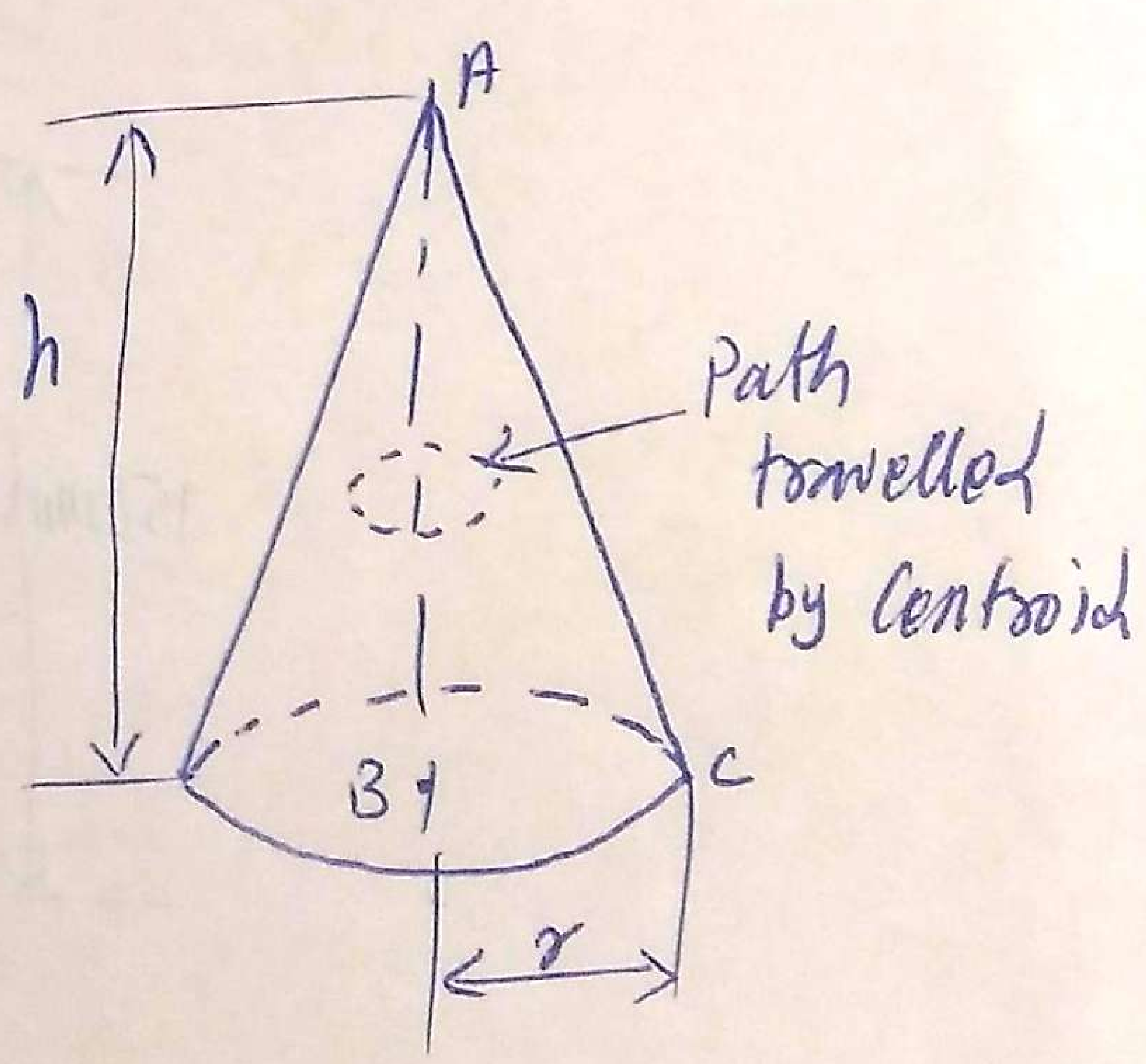
$$= \frac{2}{hb} \times \frac{h}{hb} \times \frac{h}{b} \int_0^b x^2 \cdot dx.$$

$$= \frac{h}{b^3}\left[\frac{x^3}{3}\right]_0^b = \frac{h}{b^3}\left[\frac{b^3}{3}\right]$$

$$\boxed{\bar{y} = \frac{b}{3}}$$

(ii) Volume of cone using Pappus - Guldinius theorem.





Generating area $= \frac{1}{2} rh$.

Distance of centroid from fixed axis $\Big\}\ \bar{x} = \frac{r}{3}$

Distance travelled by centroid $= 2\pi\bar{x}$

$= 2\pi\left(\frac{r}{3}\right)$

Applying Pappus - Guldinus theorem

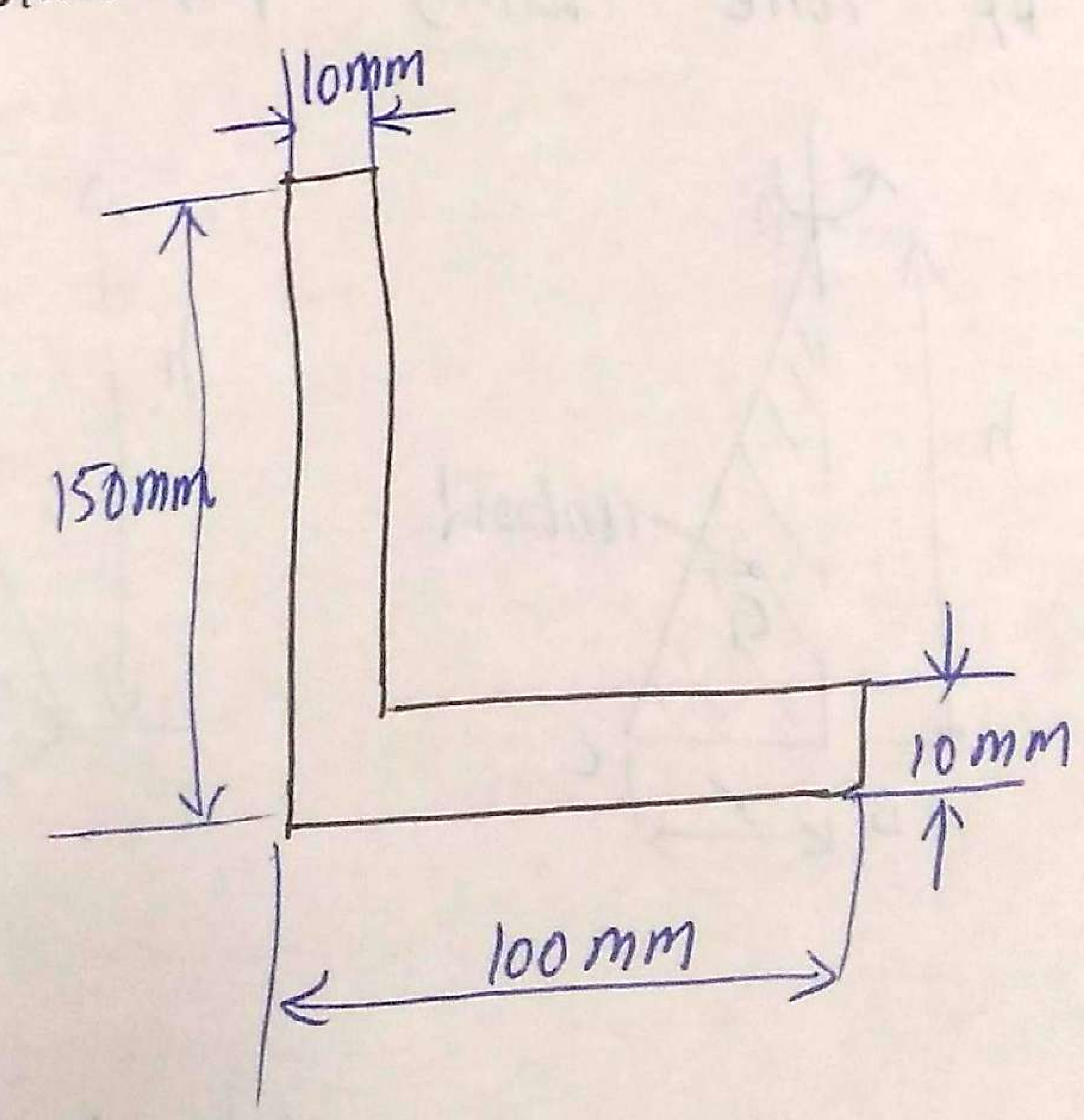
Volume Generated = Distance travelled by centroid of area × Generating area

$= \left(\frac{2}{3}\pi r\right)\times\left(\frac{1}{2}rh\right)$

$$\boxed{\text{Volume of cone} = \frac{1}{3}\pi r^2 h.}$$

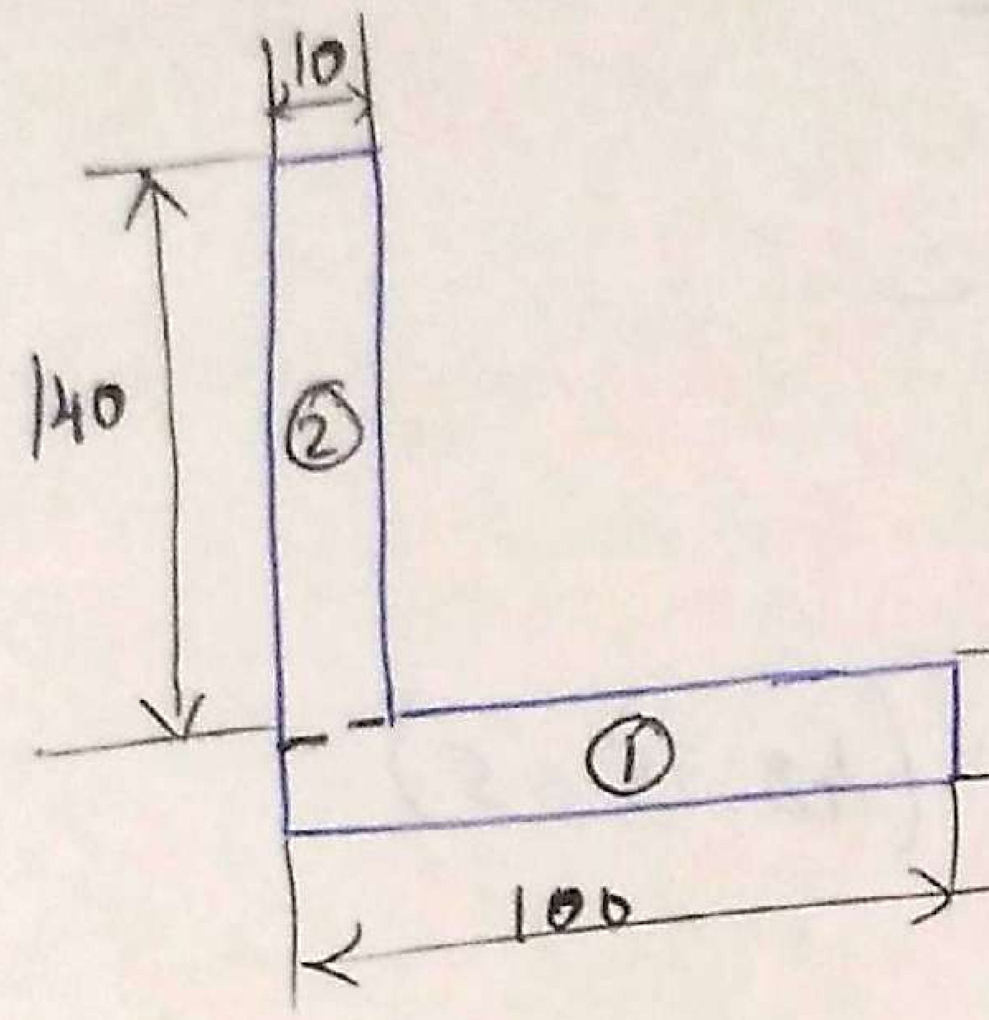
(OR)

13) b) Given data:



To Find: I_{xx} & I_{yy} : ?

Solution:



First, divide the L-section into two rectangles.

(i) 1-section:

$$A_1 = 100 \times 10 = 1000\, mm^2$$

$$x_1 = l/2 = \frac{100}{2} = 50\, mm$$

$$y_1 = b/2 = \frac{10}{2} = 5\, mm$$

(ii) 2-section:

$$A_2 = 140 \times 10 = 1400\, mm^2$$

$$x_2 = l/2 = 10/2 = 5\, mm$$

$$y_2 = 10 + b/2 = 10 + \frac{140}{2} = 80\, mm$$

$$\bar{x} = \frac{a_1 x_1 + a_2 x_2}{a_1 + a_2}$$

$$= \frac{(1000 \times 50) + (1400 \times 5)}{2400}$$

$$\boxed{\bar{x} = 23.75\, mm}$$

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2} = \frac{(1000 \times 5) + (1400 \times 80)}{2400}$$

$$\boxed{\bar{y} = 48.75\, mm}$$

moment of Inertia about xx - Centroidal axis:

$$I_{xx} = I_{xx_1} + I_{xx_2}$$

$$I_{xx_1} = \frac{bd^3}{12} + A_1 \bar{h}_1^2$$

$$\bar{h}_1 = (\bar{y} \sim y_1) = (48.75 \sim 5)$$

$$\bar{h}_1 = 43.75 \text{ mm}$$

$$I_{xx_1} = \left(\frac{100 \times 10^3}{12}\right) + 1000 \times 43.75^2$$

$$\boxed{I_{xx_1} = 1.922 \times 10^6 \text{ mm}^4}$$

$$I_{xx_2} = \frac{bd^3}{12} + A_2 \bar{h}_2^2$$

$$\bar{h}_2 = (\bar{y} \sim y_2) \Rightarrow (48.75 \sim 80)$$

$$\bar{h}_2 = 31.25 \text{ mm}$$

$$I_{xx_2} = \frac{10 \times 140^3}{12} + (1400 \times 31.25^2)$$

$$\boxed{I_{xx_2} = 3.653 \times 10^6 \text{ mm}^4}$$

$$I_{xx} = I_{xx_1} + I_{xx_2}$$

$$\boxed{I_{xx} = 5.576 \times 10^6 \text{ mm}^4}$$

moment of Inertia about vertical centroidal axis:

$$I_{yy} = I_{yy_1} + I_{yy_2}$$

$$I_{yy_1} = \frac{db^3}{12} + A_1 \bar{h}_1^2$$

$$\bar{h}_1 = (\bar{x} \sim x_1) = (23.75 \sim 50)$$

$$\bar{h}_1 = 26.25 \text{ mm}$$

$$I_{yy_1} = \left(\frac{10 \times 100^3}{12}\right) + (1000 \times 26.25^2)$$

$$\boxed{I_{yy_1} = 1.52 \times 10^6 \text{ mm}^4}$$

$$I_{yy_2} = \frac{db^3}{12} + A_2 \bar{h}_2^2$$

$$\bar{h}_2 = (\bar{x} \sim x_2) = (23.75 \sim 5)$$

$$\bar{h}_2 = (18.75 \text{ mm}$$

$$I_{yy_2} = \left(\frac{140 \times 10^3}{12}\right) + 1400 \times 18.75^2$$

$$\boxed{I_{yy_2} = 0.504 \times 10^6 \text{ mm}^4}$$

$$I_{yy} = I_{yy_1} + I_{yy_2}$$

$$\boxed{I_{yy} = 2.0262 \times 10^6 \text{ mm}^4}$$

Result:

$$I_{xx} = 5.576 \times 10^6 \text{ mm}^4$$

$$I_{yy} = 2.0262 \times 10^6 \text{ mm}^4$$

14) a) Given data:

$S_8 = d_8 = 33 m$ & $S_{13} = d_{13} = 53 m.$

To Find:

$v = ?$ & $\alpha = ?$

Solution:

$S_n = u + \frac{a}{2}(2n-1)$

$S_8 = u + \frac{a}{2}[(2\times8)-1] = 33$ ... (A)

$S_{13} = u + \frac{a}{2}[(2\times13)-1] = 53$ ... (B)

$S_8 = u + \frac{a}{2}[25] = 33 \Rightarrow u + \frac{7.5a}{2} = 33$ ... (i)

$u + 12.5a = 53$ ... (ii)

Solving both equations:

$u + 12.5a = 53$

$\underset{(-)}{u} \underset{(-)}{+} 7.5a = \underset{(-)}{33}$

$5a = 20$

$\boxed{a = 4 m/s^2}$

Put $a = 4 m/s^2$ in eqn(i) & (ii)

$u = 53 - (12.5\times4)$

$\boxed{u = 3 m/s}$

Result: $\boxed{a = 4 m/s^2}$ $\boxed{u = 3 m/s}$

14) b) Given data:

$m_A = 280\,kg.$

$m_B = 420\,kg.$

To Find:

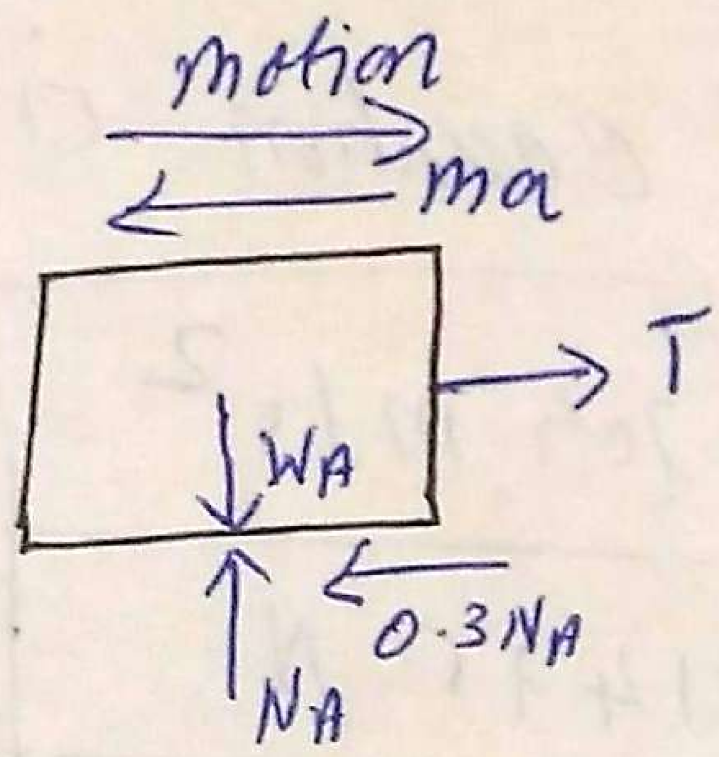
$a = ?$

$V_{3.5m} = ?$

$V_{1.5sec} = ?$

Solution:

FBD for block 1:



$\Sigma_H = 0$

$T - ma - 0.3\,N_A = 0$

$\boxed{T - (280 \times a) - 0.3\,N_A = 0}$ ... (A)

$\Sigma_V = 0$

$N_A - W_A = 0$

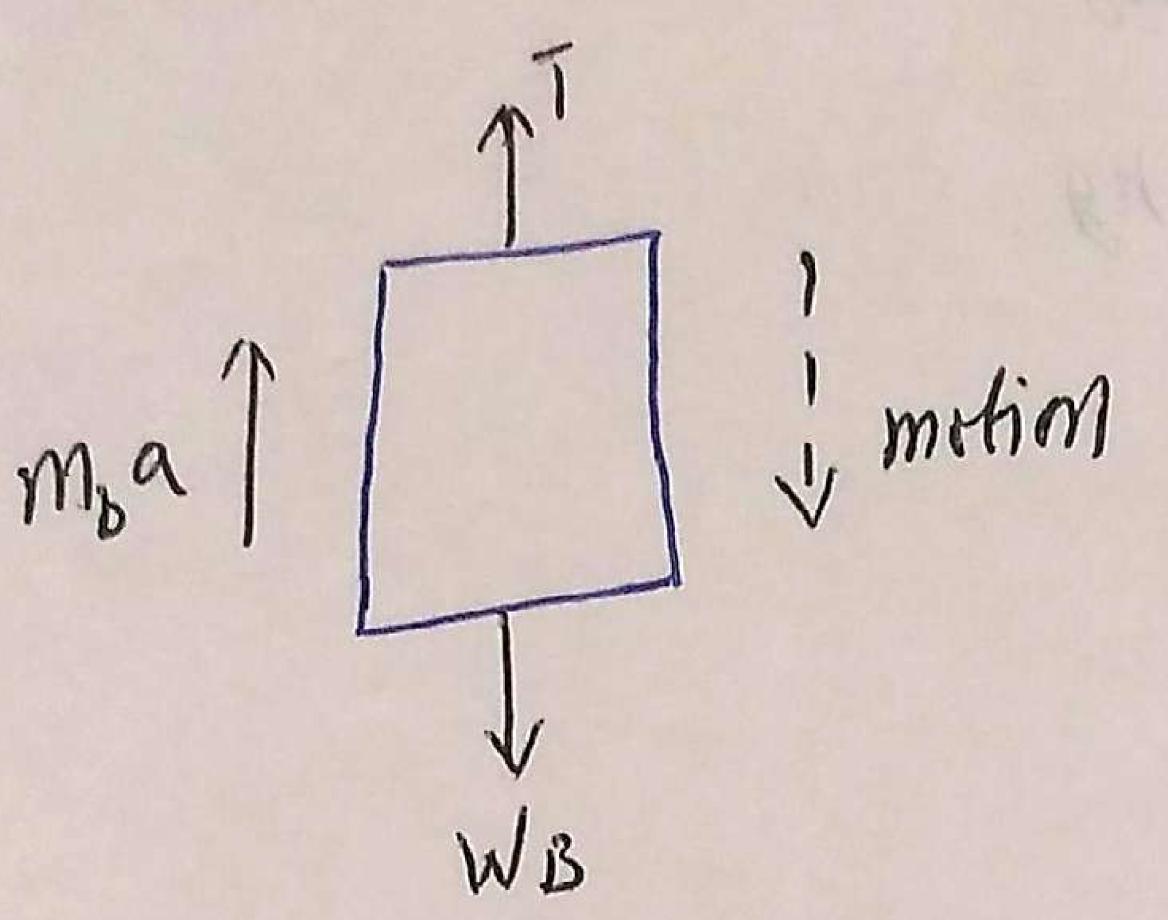
$N_A = (280 \times 9.81)$

$\boxed{N_A = 2746.8\,N.}$

Sub. N_A in equation. (A)

$\boxed{T - 280a = 824.04}$ ... i)

FBD for Block '2'



$\Sigma_V = 0$

$T + m_b a - W_B = 0$

$$\boxed{T + 420a = 4120.2} \quad \ldots (ii)$$

solving the equation (i) & (ii)

$$\boxed{a = 4.709\ m/s^2}$$

$$\boxed{T = 2142.5\ N.}$$

(ii) $V_{3.5m}$: ?

using the equations of motion

$V^2 = u^2 + 2aS$

$V = 0 + \sqrt{2 \times 4.709 \times 3.5}$

$$\boxed{V = 5.74\ m/s}$$

(iii) $V_{1.5sec}$: ?

$V = u + at$

$V = 0 + (4.709 \times 1.5)$

$$\boxed{V = 7.064\ m/s}$$

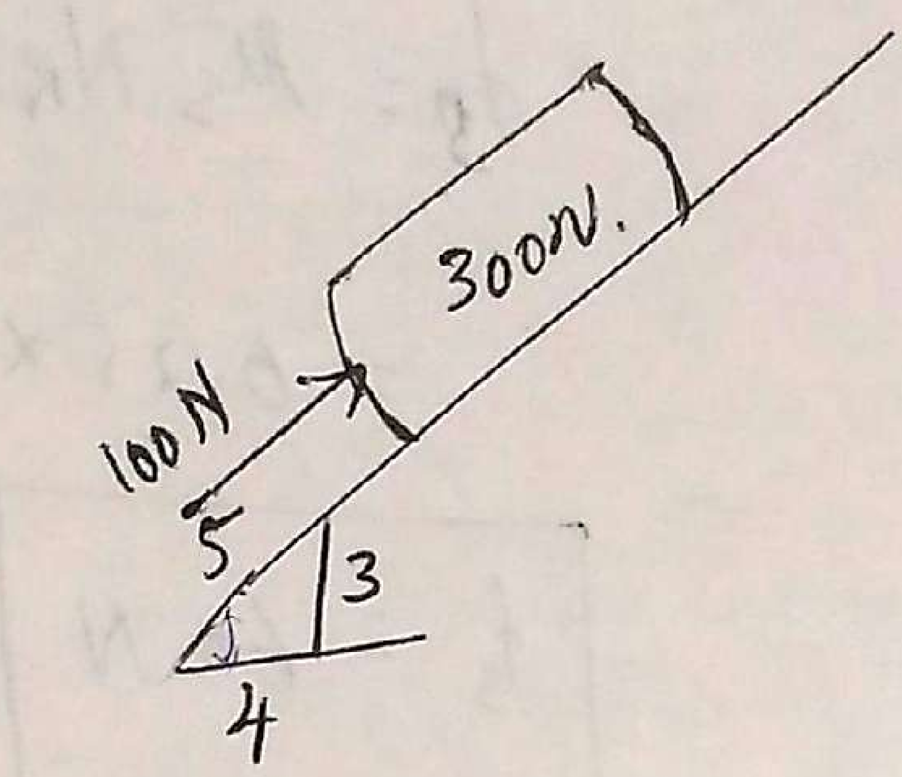
15) a) Given data:

$F = 100N$.

$W = 300N$

$\mu_S = 0.25$

$\mu_K = 0.20$



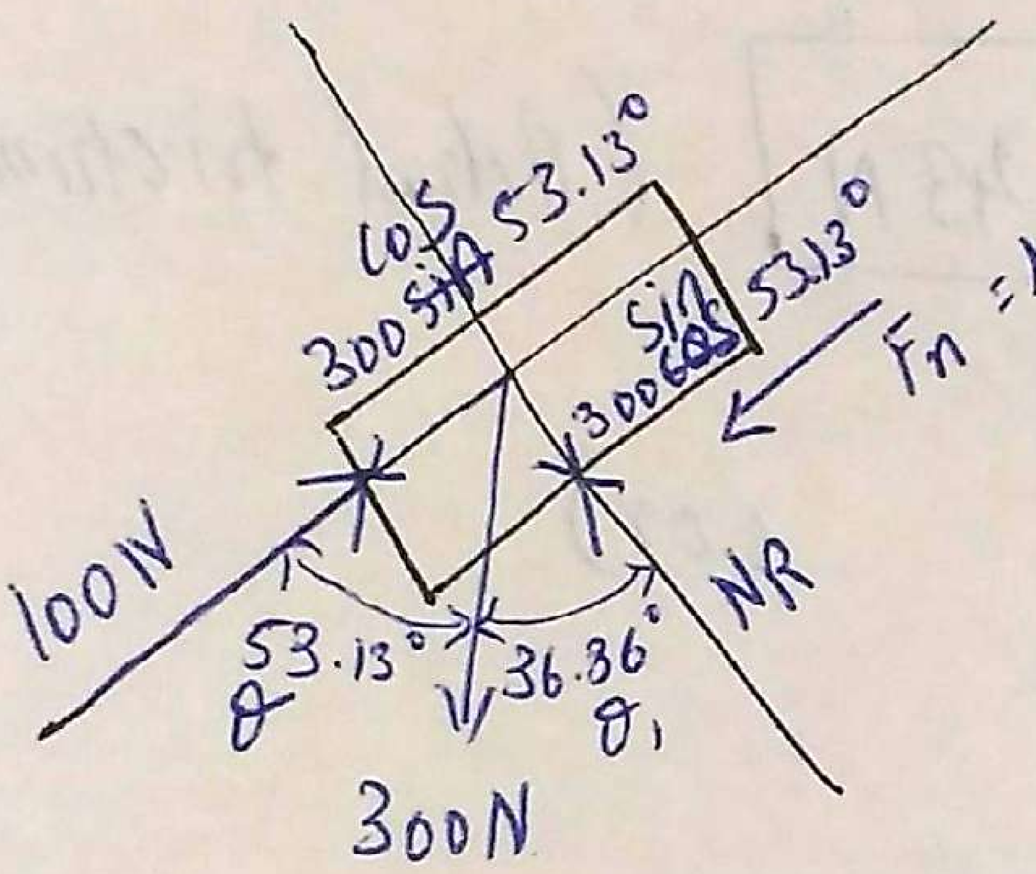
To Find:

$f_n = ?$

Equilibrium = ?

Solution:

FBD for ~~B~~ Block:



$$\theta_1 = \tan^{-1}\left(\tfrac{3}{4}\right) = 36.86^\circ$$

Apply i) $\Sigma_V = 0$

$$N_R - 300 \overset{\sin}{\cancel{\cos}}\ 53.13^\circ = 0$$

$$\boxed{N_R = 240\ N}$$

(ii) $\Sigma_H = 0$

$$100 - \mu N_R - 300 \cos 53.13^\circ = 0$$

$$\boxed{F_n = -80\ N}$$

Determine frictional force.

$$f_s = \mu_s N_R$$

$$= 0.25 \times 240$$

$$\boxed{f_s = 60\ N}$$

$$\boxed{f_s > f_n}$$

So the block is not in equilibrium. The block will move down.

$$f_k = \mu_k \times N_R$$

$$= 0.20 \times 240$$

$\boxed{f_k = 48\ N}$ (Actual frictional force)

(or)

15) b) Given data:

$N = 2000$ rpm

$t = 10$ sec → attain the speed

$t = 100$ sec → comes to rest

uniform acceleration

To Find:

No.. of revolutions = ?

Solution:

$$\omega = \frac{2\pi N}{60} = \frac{2 \times \pi \times 2000}{60} = 209.4 \text{ rad/sec}$$

(i) Starts from rest

$$\omega_0 = 0 \text{ rad/sec}$$

$$\omega = \cancel{\omega_0}^{\,0} + \alpha t$$

$$209.4 = (\alpha \times 10)$$

$$\boxed{\alpha = 20.94 \text{ rad/sec}^2}$$

No. of revolutions:

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$(209.4)^2 = (0)^2 + (2 \times 20.94 \times \theta)$$

$$\boxed{\theta = 1047 \text{ rad.}}$$

rad $\rightarrow$ degree

$$\theta \rightarrow \frac{\theta}{2\pi}$$

$$N = \frac{1047}{(2 \times \pi)}$$

$$\boxed{N = 166.64 \text{ rev} \approx 167 \text{ rev.}}$$

(ii) Comes to rest:

Final angular velocity $\rightarrow (\omega) = 0$ rad/sec

$$\omega = \omega_0 + \alpha t$$

$$0 = 209.4 + (\alpha \times 100)$$

$$\cancel{\alpha = -20.94 \text{ rad/sec}^2}$$

$$\boxed{\alpha = -2.94 \text{ rad/s}^2}$$

$\omega^2 = \omega_0^2 + 2\alpha\theta$

$0 = (209.4)^2 - (2 \times 2.94)\theta$

$\boxed{\theta = 7457.20 \text{ rad.}}$

$\theta(\text{rad}) \rightarrow \theta(\text{degree})$

$\theta \rightarrow \frac{\theta}{2\pi}$

$N = \frac{7457.20}{(2 \times \pi)}$

$\boxed{N = 1187 \text{ rev.}}$