SAP ID - 60004200132
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Div - J1

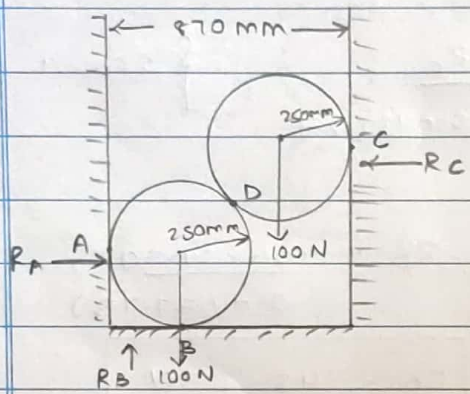
25/05/21

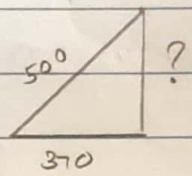
MAEER's MIT

Engineering Mechanics

Q. 2

→ a)





$$\therefore \sqrt{500^2 - 370^2} = 336.3$$

Here, $\Sigma M_D^F = 0$

$$-100 \times 370 + R_C \times 336.3 = 0$$

$$\therefore R_C \times 336.3 = 370 \times 100$$

$$\boxed{R_C = 110.021 N \ (\leftarrow)}$$

Now, $\Sigma F_y = 0$

$$R_B - 100 - 100 = 0$$

$$\therefore \boxed{R_B = 200 N \ (\uparrow)}$$

$$\Sigma F_x = 0$$

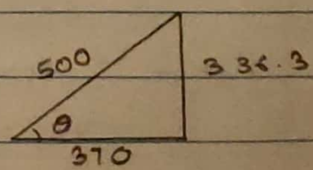
$$R_A - R_C = 0$$

$$\therefore R_A = R_C$$

$$\therefore \boxed{R_A = 110.021 N \ (\rightarrow)}$$

Now,

$$\theta = \cos^{-1}\left(\frac{370}{500}\right)$$



$$\therefore \theta = 42.27'$$

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Page 2

$\therefore$ By Lami's theorem,

$$\frac{100}{\sin(180-42.27)} = \frac{R_D}{\sin 90} = \frac{R_C}{\sin 132.27}$$

$\therefore$ ~~$R_C = \frac{100 \times \sin 132.27}{\sin(137.73)}$~~

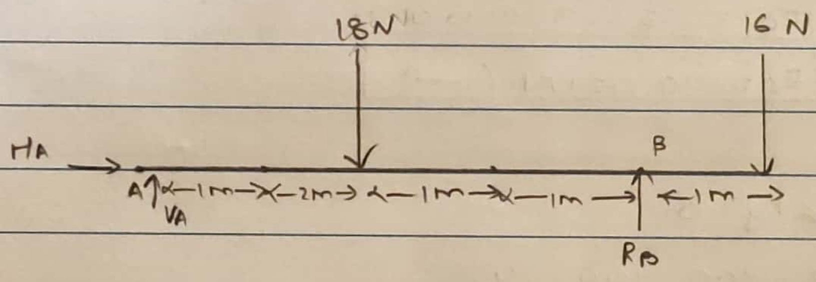
$\therefore$ ~~$R_C = 110.014\,N$~~

$$R_D = \frac{100 \times \sin 90}{\sin(137.73)}$$

$$\boxed{R_D = 148.67\,N}$$

Q.2

$\rightarrow$ b)



Now, $\Sigma F_x = 0$,

$\therefore$ $\boxed{H_A = 0}$

$\Sigma F_y = 0$

$V_A - 18 + R_B - 16 = 0$

$V_A = 18 + 16 - 30$

$\boxed{V_A = 4N \uparrow}$

$\Sigma M_A = 0$,

$-18 \times 3 + R_B \times 5 - 16 \times 6$

$\therefore$ $\boxed{R_B = 30N\,(\uparrow)}$

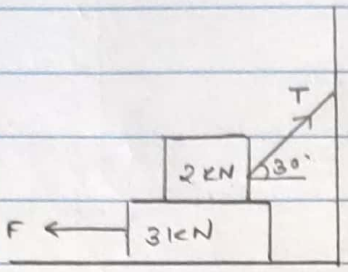
Hence, $H_A = 0$

$V_A = 4N\,(\uparrow)$

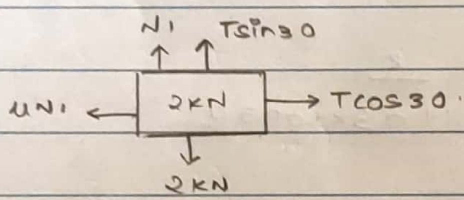
$R_B = 30\,N\,(\uparrow)$

Q. 3

→ a)



FBD of block of 2 kN,



for equilibrium,

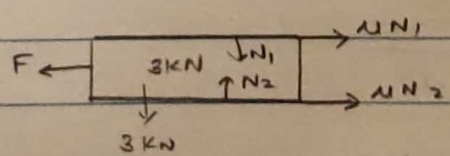
$\Sigma F_x = 0$

$T\cos 30 = \mu N_1$ — (i)

$\Sigma F_y = 0$

$N_1 + T\sin 30 = 2\ kN$ — (ii)

FBD of block of 3 kN,



$\Sigma F_x = 0$

$F = \mu N_1 + \mu N_2$ — (3)

$\Sigma F_y = 0$

$N_2 = N_1 + 3 \quad -(4)$

From (i), $T = \dfrac{\mu N_1}{\cos 30}$

Substituting in (ii)

$N_1 + \mu N_1 \tan 30 = 2$

$N_1 = \dfrac{2}{1 + \mu \tan 30} = \dfrac{2}{1 + 0.3 \times \tan 30}$

$\therefore N_1 = 1.7047 KN$

$\because N_2 = N_1 + 3 = 1.7047 + 3 \quad \ldots$ from (4)

$\therefore N_2 = 4.7047 \text{ KN}$

$\therefore$ Form (3),

$F = \mu N_1 + \mu N_2$

$= \mu (N_1 + N_2) = 0.3(1.7047 + 4.7047)$

$\therefore F = 1.92282 \text{ KN}$

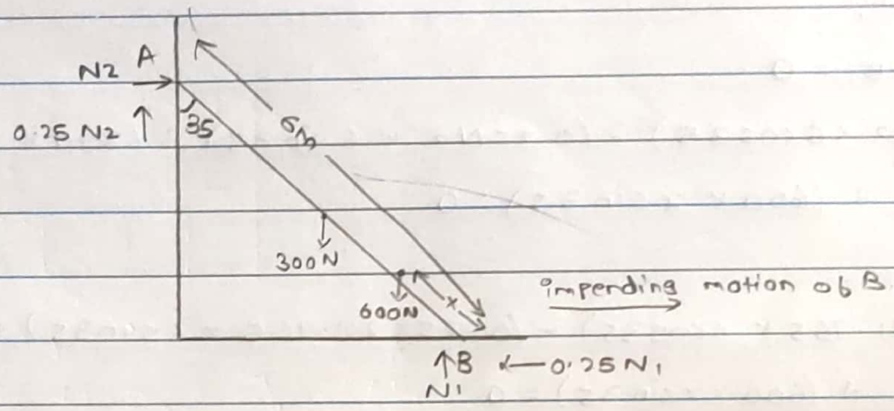
From (i) $T = \dfrac{0.3 \times 1.7047}{\cos 30}$

$\therefore \boxed{T = 0.5905 \text{ KN}}$

$\therefore$ Tension in cable is 0.5905 KN

Q. 3

→ b)



Let the person climb the distance x on the ladder when the ladder is on the verge of slipping.

The weight of ladder acts through its C.G.

Now,

Applying COE to the ladder,

$\Sigma F_x = 0$

$N_2 - 0.25N_1 = 0$ — (i)

$\Sigma F_y = 0$

$N_1 + 0.25N_2 - 300 - 600 = 0$

$\therefore 0.25N_2 + N_1 = 900$ — (2)

Solving (i) and (2), we get

$N_2 = 211.765\,N$

$N_1 = 847.059\,N$

NOW,

$\Sigma M_B = 0$

$\therefore -(N_2 \times 6\cos 35) - (0.25N_2 \times 6\sin 35) + (300 \times 3\sin 35) + (600 \times x\sin 35) = 0$

$\therefore -(211.765 \times 6\cos 35) - (0.25 \times 211.765 \times 6\sin 35) + (300 \times 3\sin 35) + (600 \times x\sin 35) = 0$

$\therefore -1040.806 - 182.195 + 516.218 + x(344.146) = 0$

$\therefore x = \dfrac{706.783}{344.146}$

$\therefore \boxed{x = 2.0537\text{ m}}$

$\therefore$ A man can climb 2.0537 m without slipping.

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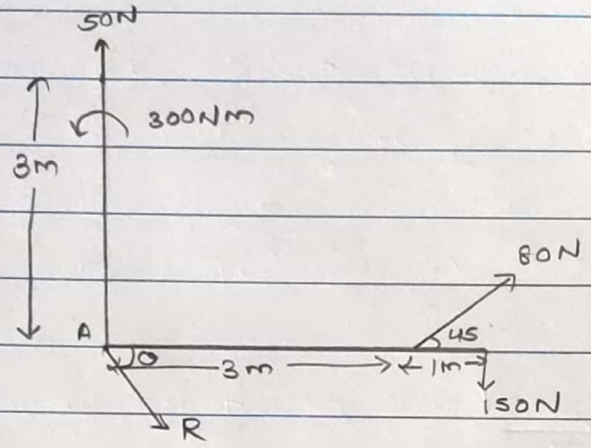
Q. 1

→ a)



$R_x = 80\cos 45 = 56.57N\ (\rightarrow)$

$R_y = 50 + 80\sin 45 - 150 = -43.43N = 43.43N\ (\downarrow)$

$\therefore\ \theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{43.43}{56.57}\right)$

$\therefore\ \boxed{\theta = 37.51^\circ\ (4^{th}\ quadrant)}$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(56.57)^2 + (43.43)^2}$

$\therefore\ \boxed{R = 71.32N}$

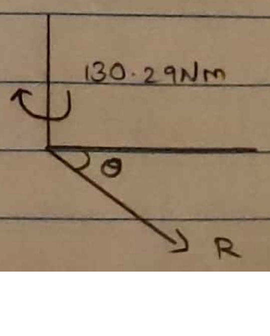
Now,

At point A,

$\Sigma M_A^F = 80\sin 45 \times 3 - 150 \times 4 + 300 = -130.29\ Nm$

$\therefore\ \Sigma M_A = 130.29\ Nm\ (\curvearrowright)$ clockwise.

∴ Resultant at A is,



where $R = 71.32N$,

$\theta = 37.51^\circ$

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Q. 1

$\longrightarrow$ b)

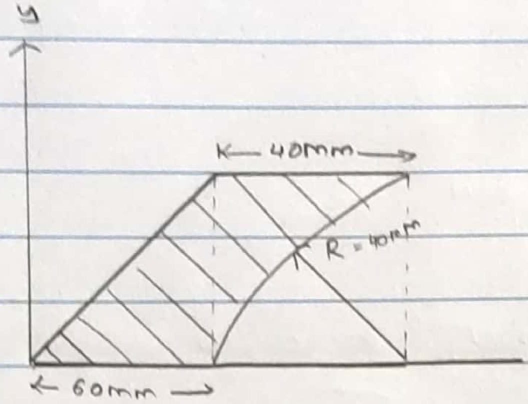
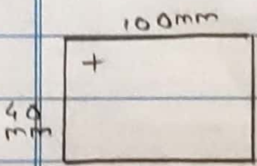
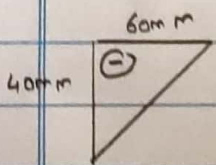
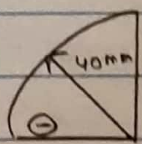


Fig	Area (mm^2)	x (mm)	y (mm)	Ax	Ay
	$100 \times 40 = 4000 mm^2$	50	20	200000	80000
	$-\frac{1}{2} \times 60 \times 40 = -1200 mm^2$	20	26.67	−24000	−32004
	$\frac{\pi \times 40^2}{4} = -1256.63 mm^2$	83.02	16.97	−104325.42	−21325.01
	$\Sigma A = 1543.37 mm^2$			$\Sigma Ax = 71674.58$	$\Sigma Ay = 26670.99$

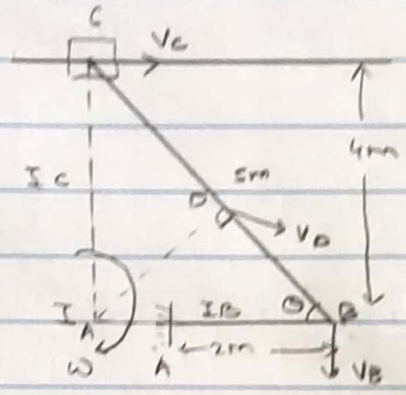
$$\therefore \bar{x} = \frac{\Sigma Ax}{\Sigma A} = \frac{71674.58}{1543.37} = 46.44 mm$$

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{26670.99}{1543.37} = 17.28 mm$$

Centroid of shaded area is (46.44, 17.28) mm

Q. 4

→ a)



$\omega_{AB} = 6 \text{ rad/s}$

For rod AB

$V_{AB} = V_B$

$V_B = r_{AB} \times \omega_{AB}$

$V_B = 2 \times 6$

$\boxed{V_B = 12 \text{ m/s}}$

$I_C = 4m$

$\therefore \sin\theta = \frac{4}{5}$

$\cos\theta = \frac{3}{5}$

$\therefore IB = 3m$

NOW,

$\therefore V_B = I_B \times \omega$

$12 = 3 \times \omega$

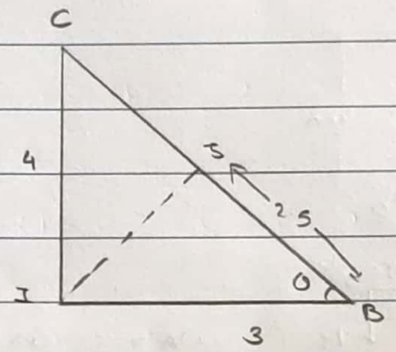
$\therefore \boxed{\omega = 4 \text{ rad/s}}$

$V_c = IC \times \omega$

$= 4 \times 4$

$\therefore \boxed{V_c = 16 \text{ m/s}}$

Let mid-point of rod be D



~~$\therefore I_D = \sqrt{3^2 - 2.5^2}$~~

~~$I_D = 1.658$ m~~

~~$\therefore V_D = I_D \times \omega$~~

~~$= 1.658 \times 4$~~

$\therefore \boxed{\cancel{V_D = 6.633 \text{ m/s}}}$

By cosine rule,

$I_D^2 = 3^2 + 2.5^2 + 2(3)(2.5)\cos\theta$

$= 9 + 6.25 + 9$

$= 24.25 \text{ m}^2$

$\therefore I_D = \underline{4.9244 \text{ m}}$

$\therefore V_D = I_D \times \omega$

$= 4.9244 \times 4$

$V_D = \underline{19.6977 \text{ m/s}}$

Q. 4

b) The sound of splash would be heard after the sound would have travelled the distance equal to depth of well.

Let depth of well be h.

Time taken to reach the sound = 3.5 s

Velocity of sound in air = 330 m/s

$\therefore$ ~~Time tal~~

$\therefore$ Time taken by stone in reaching the well,

$$h = ut + \frac{1}{2}gt^2$$

$$\therefore h = \frac{1}{2}gt^2 \quad — (1)$$

Time taken by sound of splash to reach the top of well,

$$t' = \frac{h}{330}$$

$$\therefore t' = \frac{gt^2}{2(330)} = \frac{g\,t^2}{660} = 0.014863\,t^2$$

Now,

$$t + t' = 3.5$$

$$t + \frac{t^2 g}{660} = 3.5$$

$$\therefore t + 0.014863\,t^2 = 3.5$$

$$\therefore 0.014863t^2 + t - 3.5 = 0$$

$$\therefore t = 3.3347 \text{ or } t = -70.61$$

time cannot be negative. $\therefore t \neq -70.61$

$$\therefore t = 3.3347\,s.$$

Thus, $t' = (3.3347)^2(0.014863) = 0.165\,s$

Hence, depth of well, $h = 330 \times 0.165$

$$= 54.45m$$

$\therefore$ Depth of well is $\underline{\underline{54.45m}}$