Hall Ticket Number:

I/IV B.Tech (Regular) DEGREE EXAMINATION

DECEMBER, 2018 — **Mechanical Engineering**

First Semester — **Engineering Mechanics - I**

Time: Three Hours — **Maximum :** 50 Marks

Answer Question No.1 compulsorily. (1X10 = 10 Marks)

Answer ONE question from each unit. (4X10=40 Marks)

1. Answer all questions (1X10=10 Marks)

a) State parallelogram law of forces.

b) What is principle of transmissibility?

c) What are the equations of equilibrium of a coplanar concurrent force system?

d) How do you find the resultant of two couples?

e) State the assumptions made in the analysis of a plane truss.

f) What do you mean by angle of repose?

g) State the principle of virtual work.

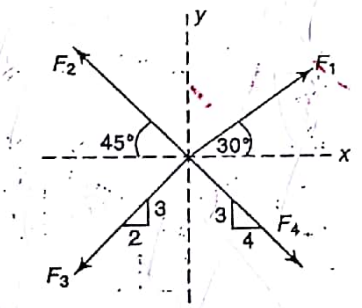
h) State Pappus-Guldinus theorem – I.

i) State perpendicular axis theorem.

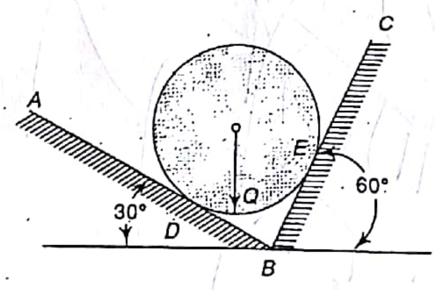
j) Where does the centroid of a three quarter circular arc of radius '*r*' lie?

UNIT – I

2.a) Find the magnitude and direction of the resultant of the four concurrent forces shown in figure. $F_1 = 1500$ N, $F_2 = 2000$ N, $F_3 = 3500$ N and $F_4 = 1000$ N. **5 M**



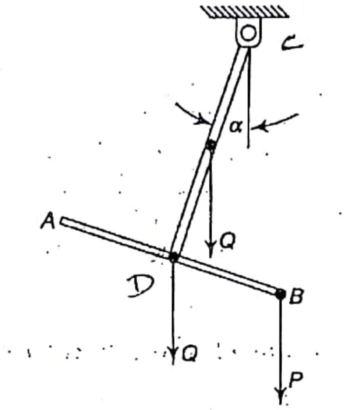
2.b) A ball of weight Q = 55 N rests in a right-angled trough, as shown in figure. Determine the forces exerted on the sides of the trough at D and E if all the surfaces are perfectly smooth. **5 M**



(OR)

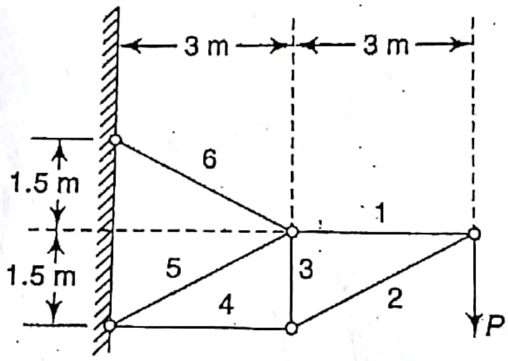
(PTO)

3. Two identical prismatic bars AB and CD are welded together in the form of a rigid T and suspended in a vertical plane as shown in figure. Calculate the angle α that the bar CD will make with the vertical when a load $P = 44.5$ N is applied at B. The weight of each bar is $Q = 22.5$ N **10 M**



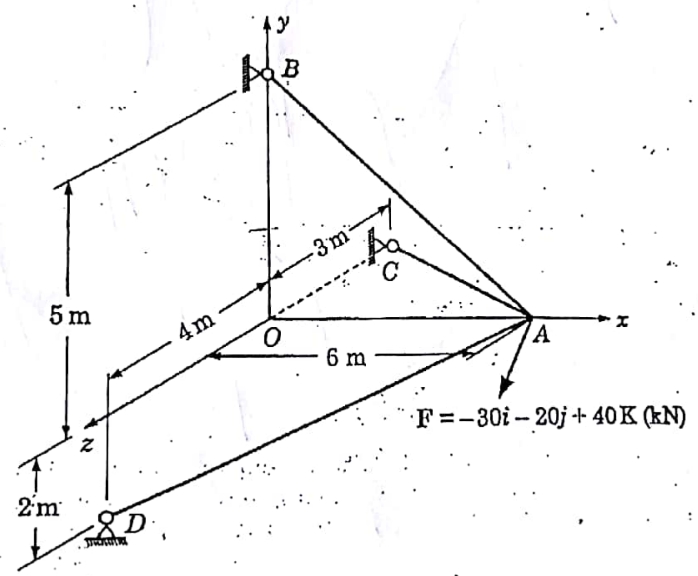
UNIT – II

4. A cantilever truss is loaded as shown in figure. Find the axial forces in all the members and specify whether the members are in tension or compression. **10 M**



(OR)

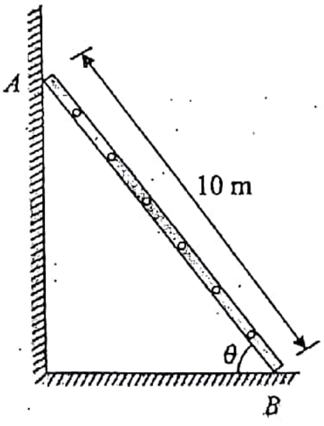
5. Determine the forces in the bars AB, AC and AD when loaded at the joint A by a force $F = -30i - 20j + 40k$ kN. **10 M**



(PTO)

UNIT – III

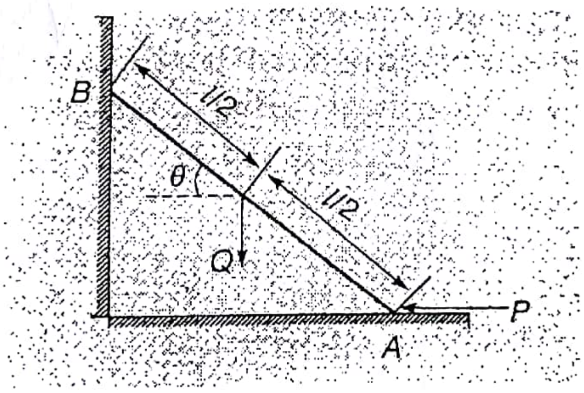
6. A 10 m long ladder rests on a horizontal floor and leans against a vertical wall. If the coefficients of friction between the ladder and floor, and between the ladder and wall are respectively 0.3 and 0.15, determine the angle of inclination of the ladder with the floor at the point of impending motion. **10 M**



(OR)

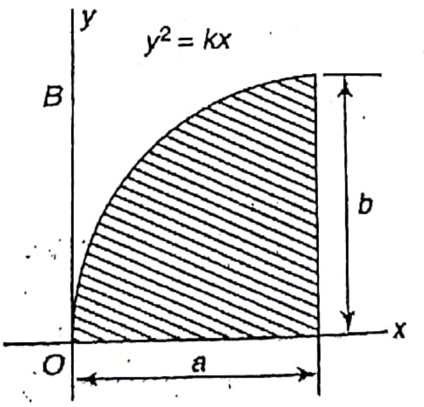
7. **10 M**

A slender prismatic bar AB of length *l* and weight Q stands in a vertical plane and is supported by smooth surfaces at A and B as shown in figure. Using the principle of virtual work, find the magnitude of the horizontal force *P* applied at A if the bar is in equilibrium.



UNIT – IV

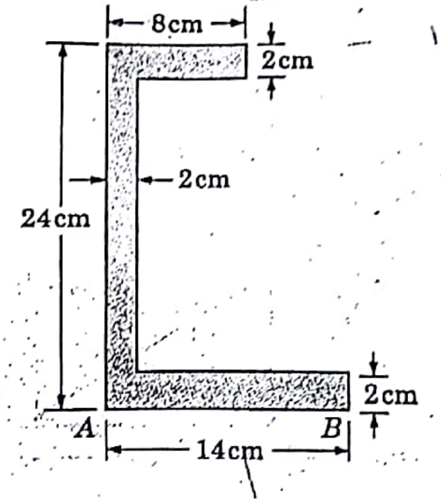
8. Determine the coordinates of centroid bounded by the parabola $y^2 = kx$, the straight line $x = a$ and x axis. **10 M**



(PTC)

(OR)

9. Determine the moments of inertia of the shaded area with respect to the centroidal axis parallel and perpendicular to side AB. **10 M**



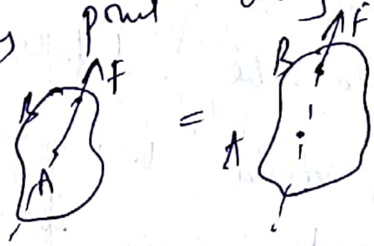
END.

Engineering Mechanics-I (18ME103)

December, 2018 I/IV B.Tech (Regular) Degree Examination

1. a) If two forces acting on a point are taken as the two adjacent sides of a parallelogram then their resultant is given by the diagonal of the parallelogram

b) The effect of a force on a body will no way be changed if its point of application is moved to any point along its line of action



c) $\Sigma F_x = 0$ & $\Sigma F_y = 0$

d) The resultant of two couples is given as the algebraic sum of the moments of the two couples.

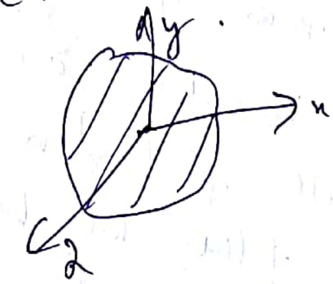
e) - All the members are connected together at their ends with frictionless hinges
- weights of the members are neglected
- loads acts only at Joints
- The axis of all the members lie in a single plane. The forces also lie in that plane.

f) The angle made by the plane with the horizontal such that a block placed on its has impending motion down the plane. Inp

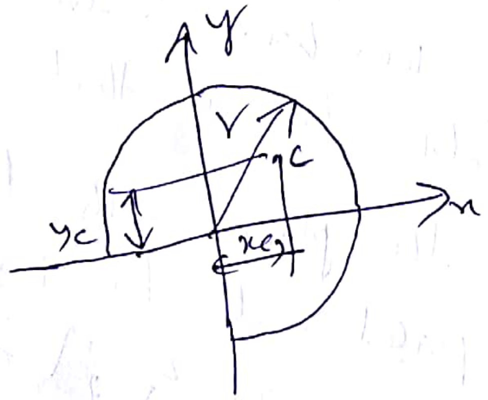
g) If a body or a system having a single degree of freedom is given a virtual displacement w.r.t. its co-ordinate from the equilibrium configuration, then the total work done by the active forces is zero $\Sigma VW = 0$

h) The area of the surface generated by rotating a plane curve about a non-intersecting axis is given as the product of the length of the curve and the distance travelled by its centroid while the surface is being generated.

i) The M.I of an area w.r.t. an axis perpendicular to the plane of the area is given as the sum of the M.I of the area w.r.t. two mutually perpendicular axis lying in the plane of the area. $I_z = I_x + I_y$.



j)

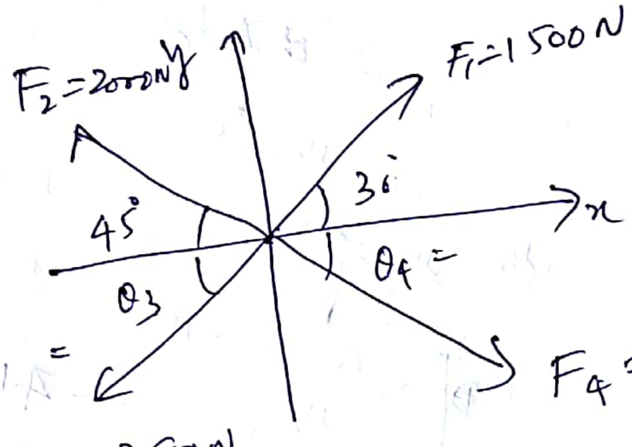


$x_c = \frac{2r}{3\pi}$ $y_c = \frac{2r}{3\pi}$.

1×10 = 10M

UNIT-I

2. a)



$\theta_3 = \tan^{-1}(3/2) = 56.31°$

$\theta_4 = \tan^{-1}(3/4) = 36.87°$ – 1M

$F_{Rx} = \Sigma F_x = 1500 \cos 30 - 2000 \cos 45 - 3500 \cos 56.31 + 1000 \cos 36.87$

$= -1256.62 N$ – 1½M

$F_{Ry} = \Sigma F_y = 1500 \sin 30 + 2000 \sin 45 - 3500 \sin 56.31 - 1000 \sin 36.87$

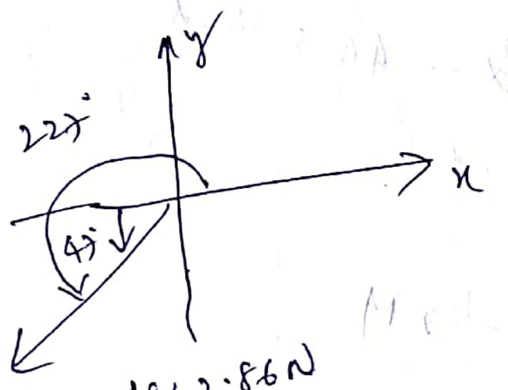
$= -1347.97 N$ – 1½M

$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2} = 1842.86 N$ – ½M

$\theta = \tan^{-1}\left(\frac{F_{Ry}}{F_{Rx}}\right) = 47°$

(or)

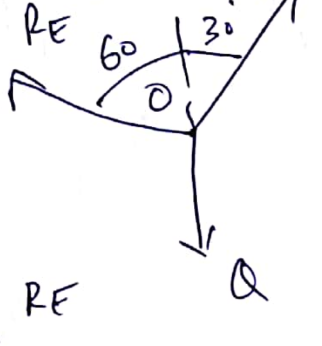
$\theta = 227°$ – ½M



$F_R = 1842.86N$ – 2M

2. b) FBD of the roller – 2M

$Q = 55N$



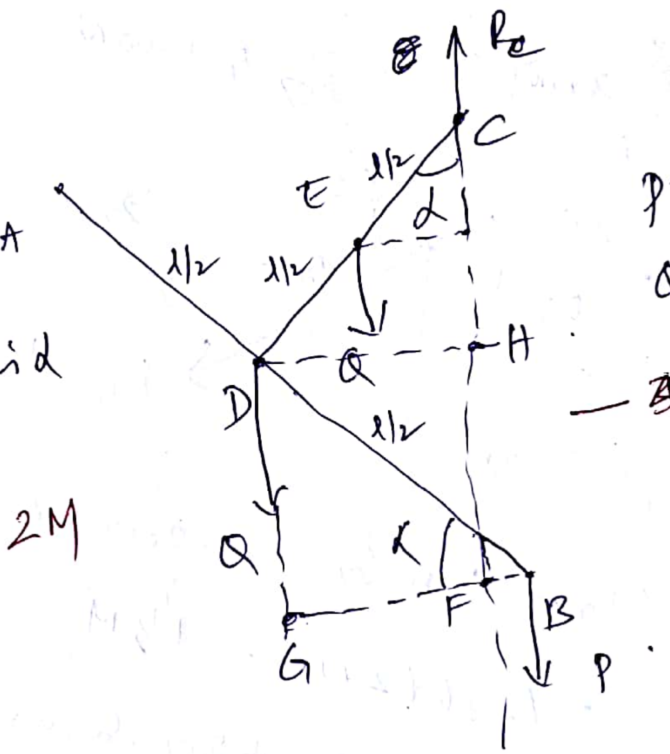
using Lami's theorem – 2M

$\frac{R_D}{\sin 120} = \frac{R_E}{\sin 150} = \frac{55}{\sin 90}$

$\Rightarrow R_D = 47.63 N$, $R_E = 27.5 N$ } 1M

(OK)

3. <u>FBD of 'T'.</u>



P = 44.5 N

Q = 22.5 N

— 4M

$\Sigma M_C = 0$

$Q \times \frac{l}{2} \sin\alpha + Q \times l \sin\alpha - P \times FB = 0$ — 2M

<u>To find FB.</u>

$FB = GB - DH$

$FB = \frac{l}{2}\cos\alpha - l \sin\alpha$

$= l\left(\frac{\cos\alpha}{2} - \sin\alpha\right)$ — 2M

$22.5 \times \frac{l}{2} \sin\alpha + 22.5 \times l \sin\alpha = 44.5 \times l\left(\frac{\cos\alpha}{2} - \sin\alpha\right)$

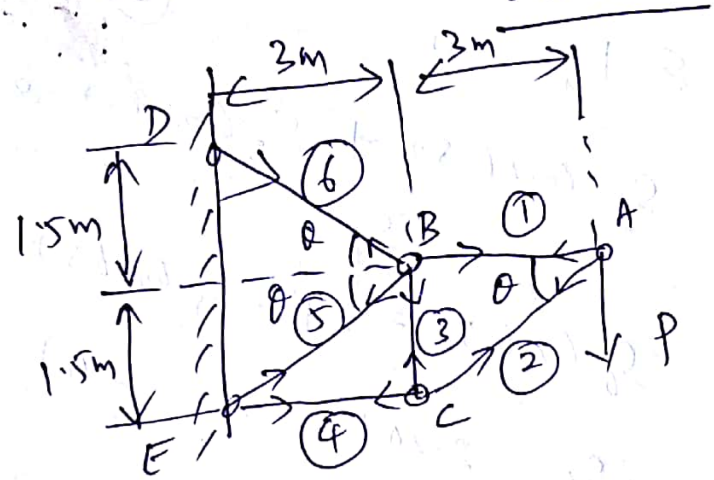
$33.75 \sin\alpha = 22.5 \cos\alpha - 44.5 \sin\alpha$

$78.25 \sin\alpha = 22.5 \cos\alpha$

$\tan\alpha = 0.287$

$\boxed{\alpha = 16.04^\circ}$ — 2M

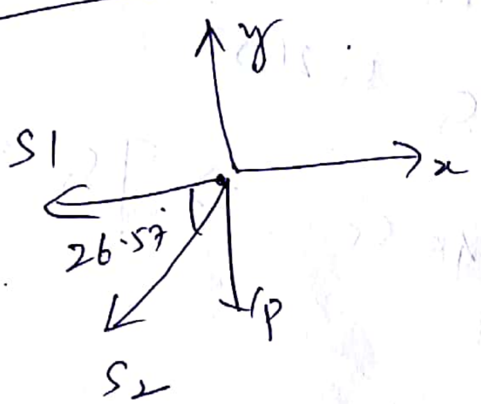
UNIT-II



$\tan\theta = \frac{1.5}{3}$

$\theta = 26.57°$

FBD of Joint-A



$\Sigma F_y = 0$

$P + S_2 \sin 26.57 = 0$

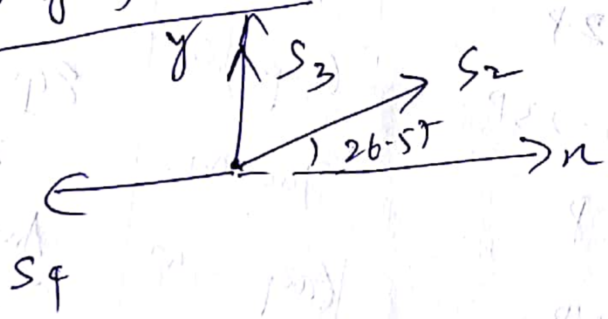
$S_2 = -2.23P$

$\Sigma F_x = 0$

$S_1 + S_2 \cos 26.57 = 0$

$S_1 = 2P$

FBD of Joint C



$\Sigma F_x = 0$

$S_2 \cos 26.57 = S_4$

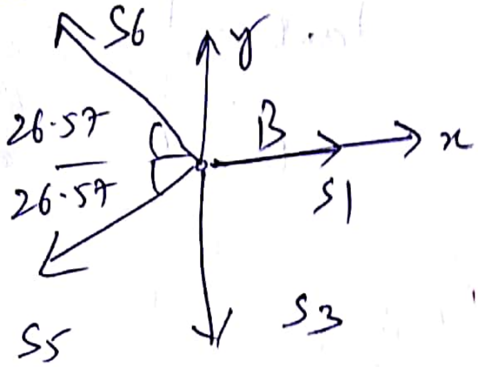
$S_4 = -2P$

$\Sigma F_y = 0$

$S_3 + S_2 \sin 26.57 = 0$

$S_3 = P$

FBD of Joint-B.



$\Sigma F_x = 0$

$S_6 \cos 26.57 + S_5 \cos 26.57 = S_1$

$S_6 \cos 26.57 = 2P - S_5 \cos 26.57$

$S_6 = 2.24P - S_5 \quad -(1)$

$\Sigma F_y = 0$

$S_6 \sin 26.57 = S_3 + S_5 \sin 26.57$

$(2.24P - S_5) \sin 26.57 = P + S_5 \sin 26.57$

$P - 0.458\, S_5 = P + 0.45\, S_5 \Rightarrow \boxed{S_5 = 0}$

$\boxed{S_6 = 2.24P}$

S.NO	Members	Internal force (N)	Nature
1	AB	2P	Tension
2	AC	2.23P	Compression
3	BC	P	Tension
4	CE	2P	Compression
5	BE	0	—
6	BD	2.24P	Tension

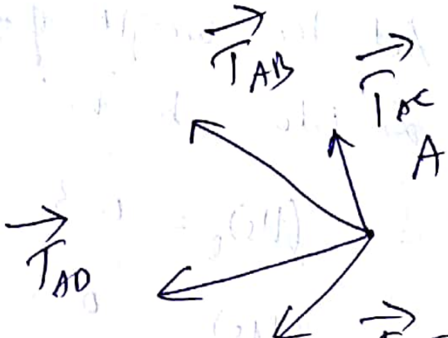
FBD's of Joints
6 Marks

Equations
2M

Answers
2M

(OR)

5. FBD of A



— 2M

Co-ordinates

A (6, 0, 0) m
B (0, 5, 0) m
C (0, 0, −3) m
D (0, −2, 4) m

$\vec{F} = -30i - 20j + 40k$ kN

$\vec{T}_{AB} = T_{AB} \frac{\vec{r}_{AB}}{r_{AB}} = T_{AB}\left[\frac{-6i + 5j}{\sqrt{6^2+5^2}}\right] = -0.77 T_{AB} i + 0.64 T_{AB} j$ — 1M

$\vec{T}_{AC} = T_{AC} \frac{\vec{r}_{AC}}{r_{AC}} = T_{AC}\left[\frac{-6i - 3k}{\sqrt{6^2+3^2}}\right] = -0.89 T_{AC} i - 0.45 T_{AC} k$ — 1M

$\vec{T}_{AD} = T_{AD} \frac{\vec{r}_{AD}}{r_{AD}} = T_{AD}\left[\frac{-6i - 2j + 4k}{\sqrt{6^2+2^2+4^2}}\right] = -0.8 T_{AD} i - 0.27 T_{AD} j + 0.53 T_{AD} k$ — 1M

$\vec{F}_R = 0 \Rightarrow \vec{F} + \vec{T}_{AB} + \vec{T}_{AC} + \vec{T}_{AD} = 0$ — 2M

$(-30 - 0.77 T_{AB} - 0.89 T_{AC} - 0.8 T_{AD}) i + (-20 + 0.64 T_{AB} ~~-0.27 T_{AB}~~$ ~~−0.45 T_{AC}~~ $- 0.27 T_{AD}) j +$ ~~(40 + 0.53 T_{AD}) k = 0~~

$+ (40 - 0.45 T_{AC} + 0.53 T_{AD}) k = 0$

$$\left.\begin{aligned}
-0.77 T_{AB} - 0.89 T_{AC} - 0.8 T_{AD} &= 30 \\
0.64 T_{AB} + 0 - 0.27 T_{AD} &= 20 \\
0 - 0.45 T_{AC} + 0.53 T_{AD} &= -40
\end{aligned}\right\}$$

Solving

$T_{AB} = 5.4$ kN

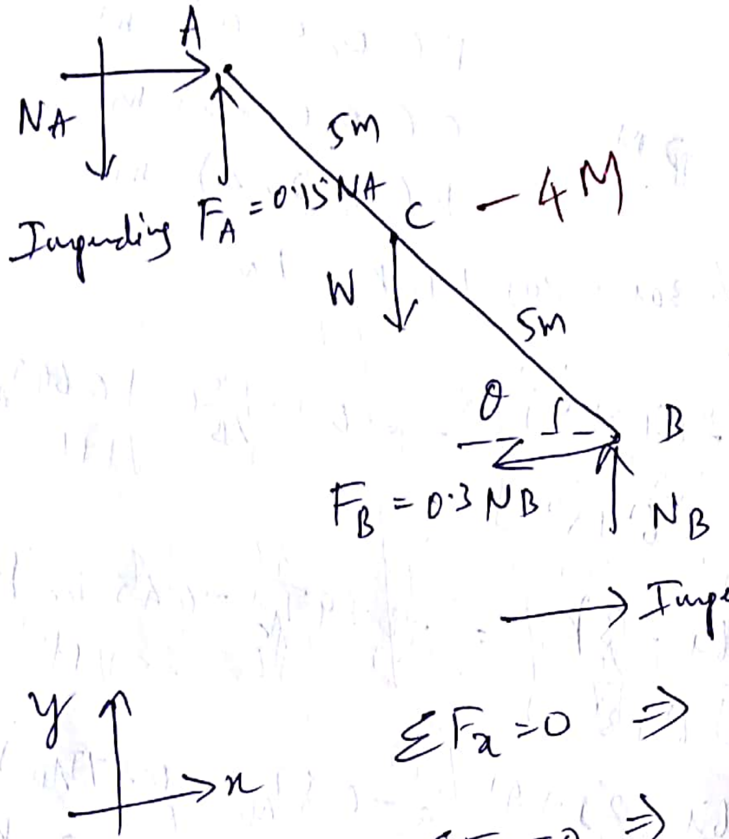
$T_{AC} = 16.71$ kN

$T_{AD} = -61.28$ kN

$T_{AB} = 5.4$ kN (T) — 1M | $T_{AC} = 16.71$ kN (T) — 1M | $T_{AD} = 61.28$ kN (C) — 1M

UNIT – III

6. FBD of the Ladder.



– 4M

Let the weight of the Ladder be 'W'

$(\mu_s)_B = 0.3$

$(\mu_s)_A = 0.15$

→ Impending

$\Sigma F_x = 0 \Rightarrow N_A - 0.3 N_B = 0$ – (1) – 1M

$\Sigma F_y = 0 \Rightarrow N_B + 0.15 N_A = W$ – (2) – 1M

(1) $\Rightarrow N_A = 0.3 N_B$

(2) $\Rightarrow N_B + 0.15 \times 0.3 N_B = W$ $\Rightarrow N_B = 0.96 W$

$\Rightarrow N_B = \frac{W}{(1+0.045)}$

$\Rightarrow N_A = 0.29 W$

$\Sigma M_B = 0$ $W \times 5 \cos\theta = 0.15 N_A \times 10 \cos\theta + N_A \times 10 \sin\theta$ – 2M

$5 W \cos\theta = 1.5 \times 0.29 W \cos\theta + 0.29 W \times 10 \sin\theta$

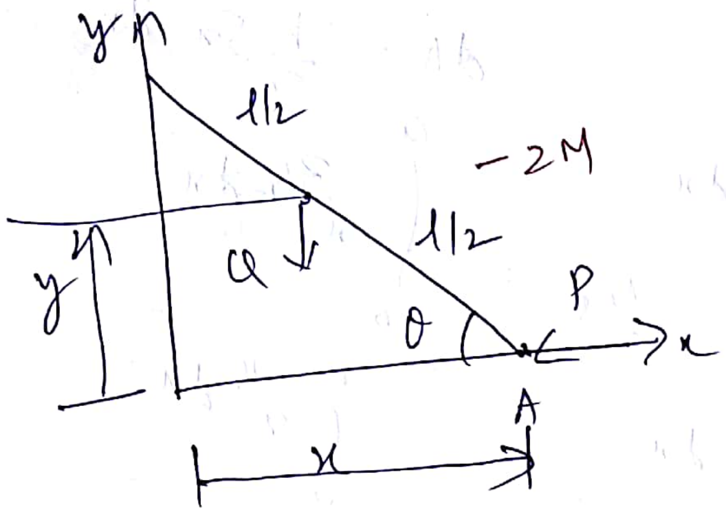
$5 \cos\theta = 0.44 \cos\theta + 2.9 \sin\theta$

$2.9 \sin\theta = 4.56 \cos\theta \Rightarrow \tan\theta = 1.57$

$\Rightarrow \boxed{\theta = 57.54^\circ}$ – 2M

(OR)

7.



$x = l\cos\theta$
$y = \frac{1}{2}\sin\theta$ } 2M

$\delta x = -l\sin\theta\,\delta\theta$

$\delta y = \frac{l}{2}\cos\theta\,\delta\theta$

– 2M

$\Sigma VW = 0$ – 2M

$-P\delta x - Q\delta y = 0 \Rightarrow P\delta x + Q\delta y = 0$

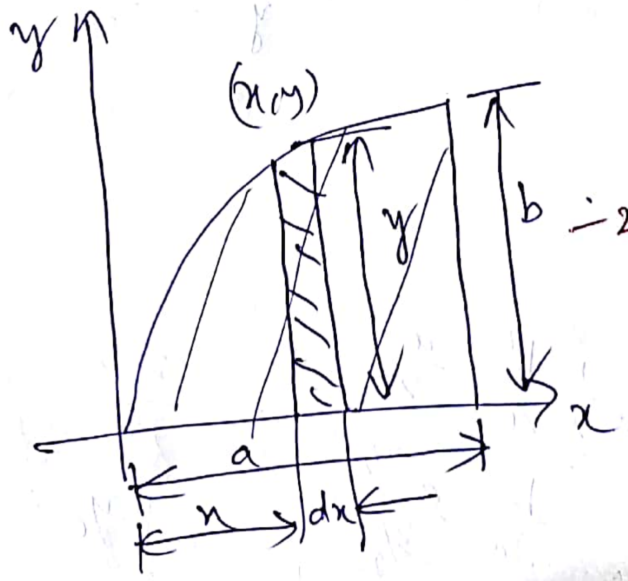
$P \times (-l\sin\theta\,\delta\theta) + Q(\frac{l}{2}\cos\theta\,\delta\theta) = 0$

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

$P = \frac{Q}{2\tan\theta} = \frac{Q}{2}\cot\theta$ – 4M

UNIT – IV

8.



– 2M

$y^2 = kx$

$x = a \quad y = b$

$b^2 = ka$

$\Rightarrow k = b^2/a$

$y^2 = \frac{b^2}{a}x$

$$x_c = \frac{\int x \, dA}{\int dA} \quad - 1M \qquad dA = y\,dx$$

$$dA = \frac{b}{\sqrt{a}} \sqrt{x}\, dx$$

$$x_c = \frac{\int_0^a x \frac{b}{\sqrt{a}} \sqrt{x}\, dx}{\int_0^a \frac{b}{\sqrt{a}} \sqrt{x}\, dx} = \frac{\int_0^a x^{3/2}\, dx}{\int_0^a x^{1/2}\, dx}$$

$$x_c = \frac{\frac{a^{5/2}}{5/2}}{\frac{a^{3/2}}{3/2}} = \frac{2a}{5} \cdot \frac{3}{2} = \frac{a \times 2}{5} \times \frac{3}{2}$$

$$\boxed{x_c = \frac{3a}{5}} \quad - 3M$$

$$y_c = \frac{\int y/2 \, dA}{\int dA} \quad - 1M \qquad dA = y\,dx$$

$$y^2 = \frac{b^2}{a} x$$

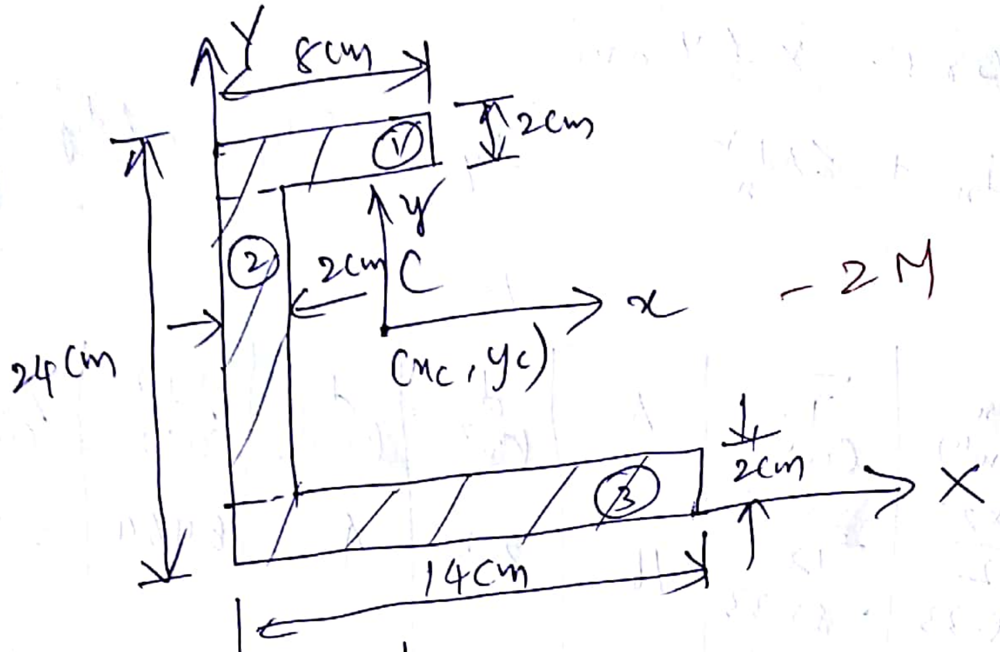
$$y = \frac{b}{\sqrt{a}} \sqrt{x}$$

$$= \frac{\int_0^a \frac{y^2}{2}\, dx}{\int_0^a y\, dx}$$

$$= \frac{\frac{1}{2}\int_0^a \frac{b^2}{a} x\, dx}{\int_0^a \frac{b}{\sqrt{a}} \sqrt{x}} = \frac{\frac{1}{2} \cdot \frac{b^2}{a} \cdot \frac{a^2}{2}}{\frac{b}{\sqrt{a}} \cdot \frac{a^{3/2}}{3/2}} = \frac{3b}{8}$$

$$\boxed{y_c = \frac{3b}{8}} \quad - 3M$$

9:



Location of Centroid

S.NO	A_i (cm^2)	x_i (cm)	y_i (cm)	A_ix_i (cm^3)	A_iy_i (cm^3)
1	8×2 = 16	4	23	64	368
2	20×2 = 40	1	12	40	480
3	14×2 = 28	7	1	196	28

$\Sigma A_i = 184\ cm^2$ $\Sigma A_ix_i = 3.00$ $\Sigma A_iy_i = 876$

$$x_c = \frac{\Sigma A_i x_i}{\Sigma A_i}$$ $$y_c = \frac{\Sigma A_i y_i}{\Sigma A_i}$$

$x_c = 3.57\ cm$ — 1½ M

$y_c = 10.43\ cm$ — 1½ M

(12)

M.I. w.r.t. X & Y axis

$I_x = \Sigma \bar{I}_x + \Sigma A d_x^2$ $I_y = \Sigma \bar{I}_y + \Sigma A d_y^2$ — 1M

S.NO	$\bar{I}_x$ (cm^4)	$\bar{I}_y$ (cm^4)	A (cm^2)	d_x (cm)	d_y (cm)	Ad_x^2 (cm^4)	Ad_y^2 (cm^4)
1	$\frac{8\times2^3}{12} = 5.33$	$\frac{2\times8^3}{12} = 85.33$	16	23	4	8464	256
2	$\frac{2\times20^3}{12} = 1333.33$	$\frac{20\times2^3}{12} = 13.33$	40	12	1	5760	40
3	$\frac{14\times2^3}{12} = 9.33$	$\frac{2\times14^3}{12} = 457.33$	28	1	7	28	1,372

$\Sigma \bar{I}_x = 1348$ $\Sigma \bar{I}_y = 556$ $\Sigma A d_x^2 = 14,252$ $\Sigma A d_y^2 = 1668$

$I_x = 15,600\ cm^4$ — 1M $I_y = 2,224\ cm^4$ — 1M

$I_x = \bar{I}_x + A y_c^2$ $I_y = \bar{I}_y + A\cdot x_c^2$

$\bar{I}_x = I_x - A y_c^2$ $\bar{I}_y = I_y - A\cdot x_c^2$

$= 15,600 - 184 \times 10.43^2$ $= 2,224 - 84 \times 3.57^2$

$= 6,462.07\ cm^4$ $\bar{I}_y = 1153.43\ cm^4$

$\boxed{\bar{I}_x = 6,462.07\ cm^4}$ — 1M $\boxed{\bar{I}_y = 1153.43\ cm^4}$ — 1M

(RVR JCCE) 10.12.21 HOD i/c

(C.D. Narayana Chandary)