Date
Page

KATHMANDU UNIVERSITY

DHULIKHEL, KAVRE

Subject: ENGG 111

Assignment No:- 1

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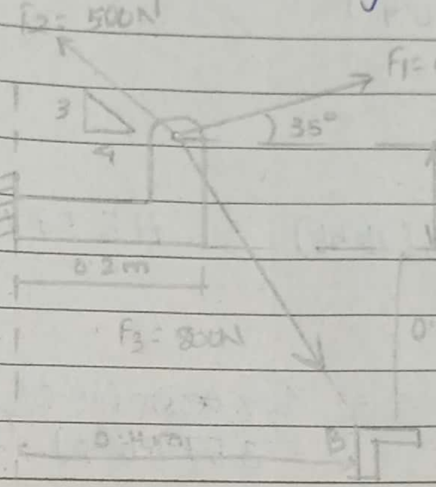
Date
Page

<Q.17>: The forces F1, F2 and F3 all of which act on point A of the bracket, are specified in three different ways. Determine the x and y scalar components of each of three forces.



Soln:

For force $F_1 = 600$ N.

Horizontal component:

$F_{H1} = F_1 \times \cos 35° = 600 \times \cos 35° = 491.49$ N

$F_{V1} = F_1 \times \sin 35° = 600 \times \sin 35° = 344.14$ N

Vertical component:

For force $F_2 = 500$N

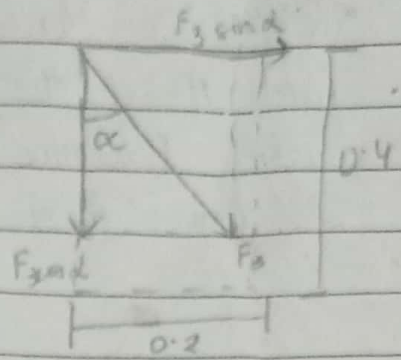
Horizontal component:

$F_{H2} = F_2 \times \cos\theta = 500 \times \frac{4}{5} = 400$ N

Vertial component: $F_{V2} = F_2 \times \sin\theta = 500 \times \frac{3}{5} = 300$ N

Date
Page

For force $F_3 = 800N$



Here,

$\alpha = \tan^{-1}\left|\frac{0.2}{0.4}\right| = 26.56.$

Horizontal component:

$F_{3H} = F_3 \times \cos\alpha$

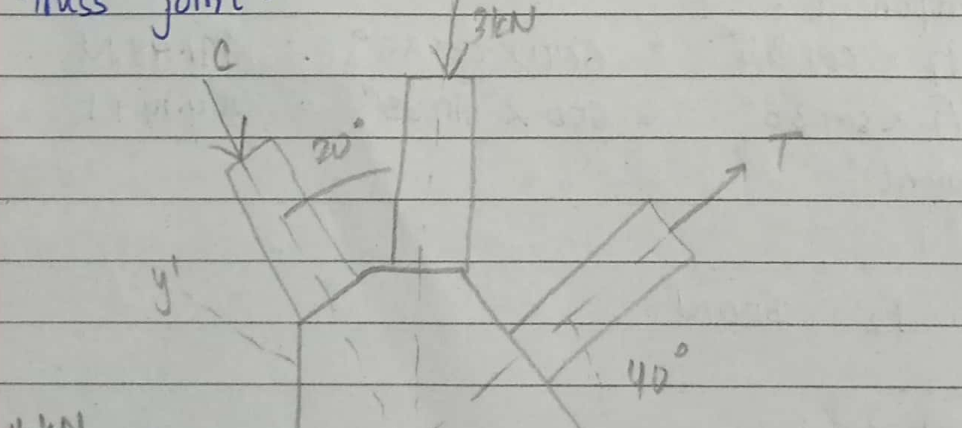
$= 800 \times \cos(26.56) = 715.57\ N$

Vertical component:

$F_{3V} = F_3 \times \sin\alpha = F_3 \times \sin(26.56)$

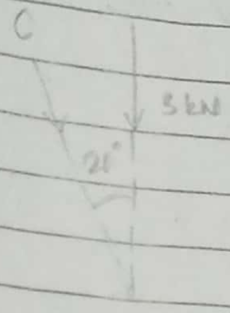
$= 357.70\ N$

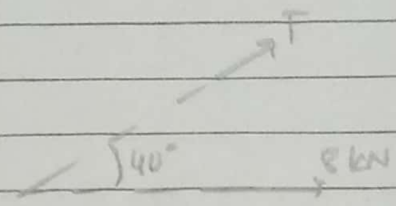
(2): Determine the force C and T along with the other three forces shown, act on the bridge truss joint.



Soln:

From figure,





Here,

$C\cos\theta = 3$

or $C = \dfrac{3}{\cos 20^\circ}$

$\therefore C = 3.192\text{kN}$ (↓↘)

Here,

$T\cos\theta = 8$ kN

or, $T = \dfrac{8}{\cos 40^\circ}$

$\therefore T = 10.44$ kN (↗)

We know,

$(\rightarrow) \sum F_x = 0$

or, $8 + T\cos 40^\circ + C\sin 20^\circ - 16 = 0$

or, $0.766T + 0.342C = 8$ — (a)

$(\uparrow) \sum F_y = 0$

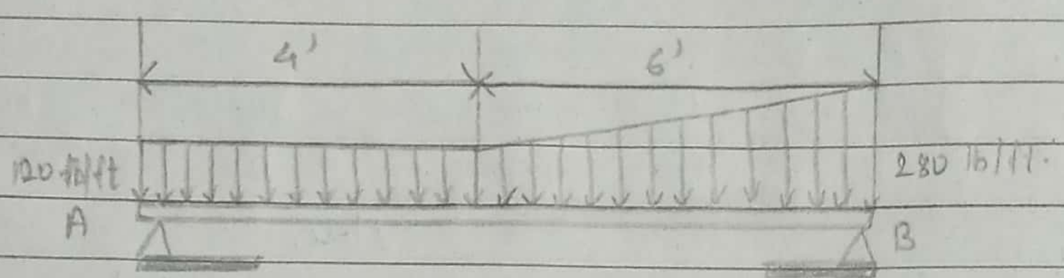
or, $T\sin 40^\circ - C\cos 20^\circ - 3 = 0$

or $0.643T - 0.940C = 3$ — (b).

Solving eq^n (i) and (ii);

$T = 9.09$ kN $\qquad C = 3.03$ kN

(3) Determine the equivalent concentrated load(s) and external reactions for the simply supported beam which is subjected to the distributed load shown.



The equivalent loads acting;

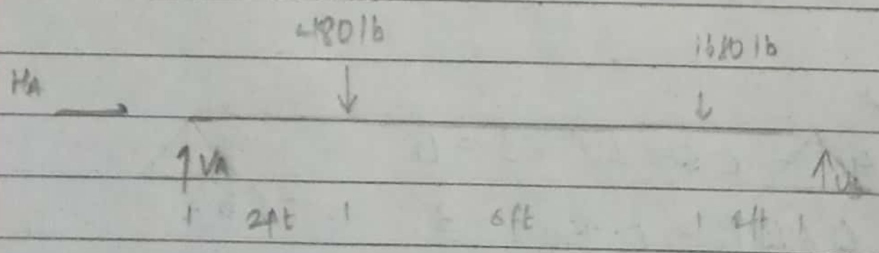
$w_1 = 120 \times 4$

$= 480$ lb at 2 ft from A

$w_2 = 280 \times 6$

$= 1680$ lb at 2 ft from B

The free body diagram is;



Date
Page

At equilibrium, $\sum F_x = 0$, $\sum F_y = 0$, $\sum M_A = 0$

So,

$(\overrightarrow{+})$ $\sum F_x = 0$

$\therefore H_A = 0$

Also,

$(+\uparrow)$ $\sum F_y = 0$

or $V_A - 480 - 1680 + V_B = 0$

or $V_A + V_B = 2160$ — (i)

Now,

$\sum M_A = 0$

or, $-480 \times 2 - 1680 \times 8 + V_B \times 10 = 0$

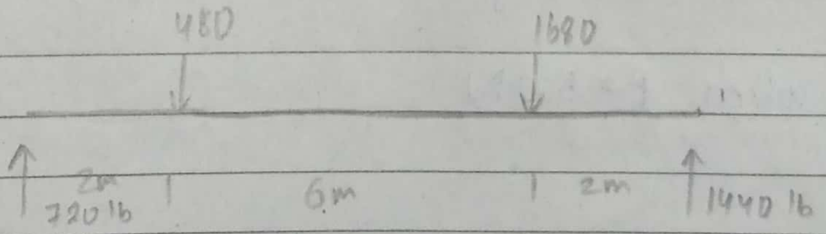
or, $10 V_B = 14400$

$\therefore V_B = 1440$ lb $(\uparrow)$

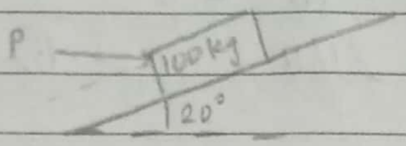
So, $V_A + V_B = 2160$

or, $V_A = 720$ lb $(\uparrow)$

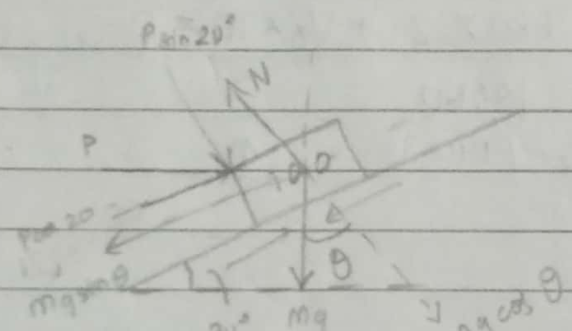
Hence, the final equilibrium,



4) Determine the magnitude and direction of the friction force acting on the 100 kg block shown if first, P = 500 N and second P = 100 N. The coefficient of static friction 0.20 and the coefficient of KE is 0.17. The forces are applied with the block initially at rest.



Soln:



~~Since the~~ Here, [∵ Initially, the block is at rest]

$\Sigma F_x = 0$ and $\theta = 20°$

So,

$$P\cos 20° - mg\sin 20° + f = 0$$

and

Reaction $(R) = mg\cos 20° + P\sin 20°$

So when $P = 500\,N$

Date
Page

$500 \cos 20° - 100 \times 9.81 \times \sin 20° + f = 0$ — (i).

$R = 100 \times 9.81 \times \cos 20° + 500 \times \sin 20°$ — (ii)

Here,

$f_{max} = \mu_s R$

$= 0.20 \times (100 \times 9.81 \times \cos 20° + 500 \times \sin 20°)$

$= 218.57$ N.

From eq^n (i);

$500 \cos 20° - 100 \times 9.81 \times \sin 20° + f = 0$

$\therefore f = 981 \sin 20° - 500 \cos 20°$

$= -134.8 \text{ N} < 218.57.$

Here, the block moves ~~downward~~ upward as frictional force acts downward.

when $P = 100$ N,

~~fmax~~ $100 \times \cos 20° + f - 981 \sin 20° = 0$ — (iii)

$R = 981 \cos 20° + 100 \sin 20°$ — (iv)

$f_{max} = \mu_s R$

$= 0.20 \times (981 \cos 20° + 100 \sin 20°)$

$\therefore f_{max} = 191.21$ N

from eq^n (iii),

$100 \times \cos 20° - 981 \sin 20° + f = 0$

or $f = 981 \sin 20° - 100 \cos 20°$

$\therefore f = 241.55 > 191.2$ N (Not possible).

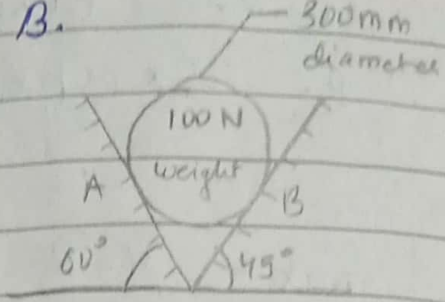
So, $f_k = 0.17 \times (956.04) = 162.52$ N

frictional force acts upward.

cos θ sin θ

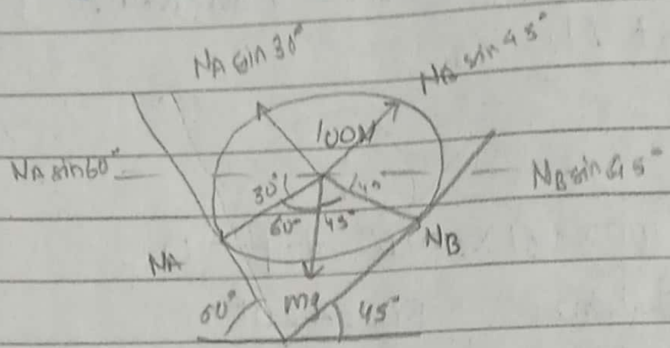
Date
Page

(5): Determine reactions at A and B.



Soln.

The free body diagram;



From free body diagram,

$\sum Fx = 0$

or, $N_A \sin 60° - N_B \sin 45° = 0$

or $\frac{\sqrt{3}}{2} N_A - \frac{1}{\sqrt{2}} N_B = 0$ — (i).

Also,

$\sum F_y = 0$

or, $mg - N_A \sin 30° - N_B \sin 45° = 0$

or $100 = N_A \times \frac{1}{2} - N_B \times \frac{1}{\sqrt{2}}$

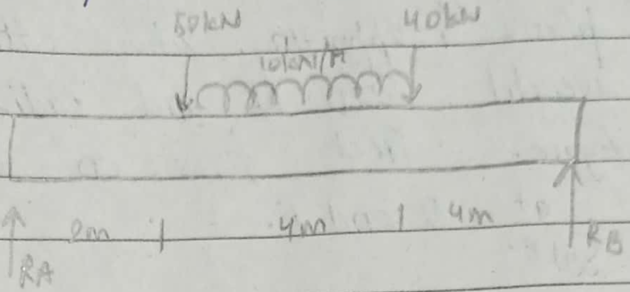
or $\frac{1}{2} N_A - \frac{1}{\sqrt{2}} N_B = 100$ — (ii)

Solving (i) and (ii), we get.

$N_A = 73.20\ N$

$N_B = 89.66\ N$

(6): A simply supported beam of 10 m length carries two point loads and uniformly distributed load. Calculate the reaction force.



Solⁿ.

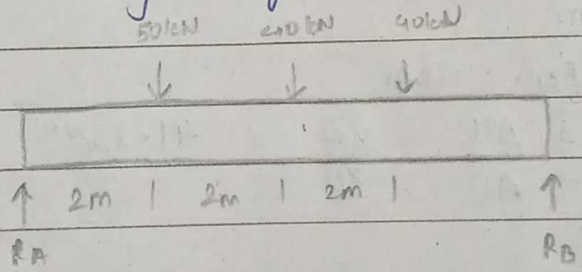
The equivalent workdone.

w_1 = 40 kN at 4 m from A.

w_2 = 50 kN at 2 m from A

w_3 = 40 kN at 6 m from A

The free body diagram:



At equilibrium, $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma M_A = 0$

So, (↑+) $\Sigma F_y = 0$

or, $R_A - 50 - 40 - 40 + R_B = 0$

or, $R_A + R_B = 130$ — (i).

And (+↻) $\Sigma M_A = 0$

or, $R_A \times 0 + 50 \times 2 + 40 \times 4 + 40 \times 6 \cancel{=0} - 10 R_B = 0$

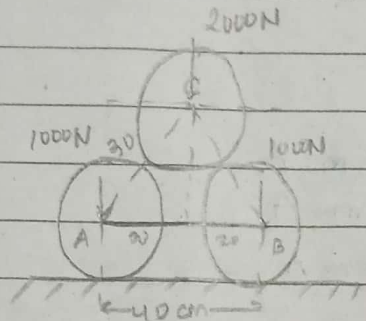
$\therefore$ $R_B = 50$ kN

So, $R_A = 130 - 50 = 80$ kN

Date
Page

Q7: Two smooth circular cylinders each of weight 1000N and radius 15 cm are connected in centre by a string AB of length 40 cm and rest upon a horizontal plane, supporting above them a third cylinder of weight 2000 N and radius 15cm as shown as in figure. Find force on the string AB and reactions at D and E.

Soln.



In ΔABC, H is midpoint.

So, $AH = HB = 20cm$

$AC = AF + FC = 15 + 15cm = 30cm.$

In ΔACH, $\sin\theta = \frac{AH}{AC} = \frac{20}{30} = 41.836°$

In cylinder C,

$RF \sin\theta = RG \sin\theta$

or $RF = RG.$

Also,

$\Sigma F_y = 0$

or $Rf \cos\theta + RG \cos\theta = 2000$

or $2 Rf \cos\theta = 2000.$

$\therefore Rf = 1342.18$ N.

Date
Page

Here, in cylinder A;

$\Sigma F_x = 0$

or, $F_{AB} - R_f \sin\theta = 0$

$F_{AB} = R_f \sin\theta$

$= 1342.18 \times \sin 41.836$

$\therefore F_{AB} = 895.2\ N.$

$\Sigma F_y = 0$

$N_D - 1000 - R_f \cos\theta = 0$

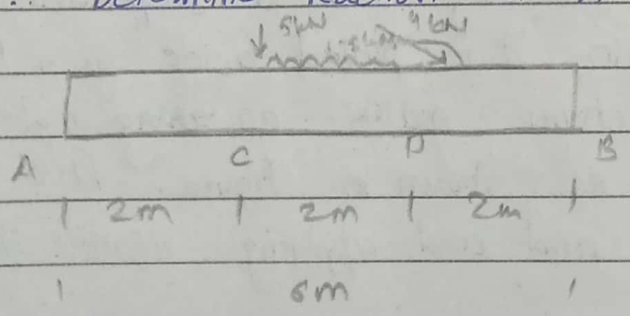
$\therefore N_D = 200N.$

Since $R_F = R_G$,

So,

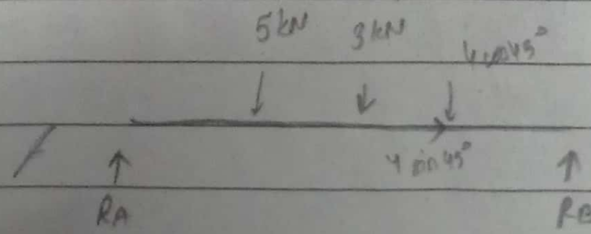
$N_E = 2000N.$

(8): A beam AB 6m long is loaded as shown in figure. Determine reaction at A and B.



Soln.

The free body diagram;



Date
Page

From free body diagram;

$$\Sigma F_y = 0$$

or $R_A + R_B - 5 - 4\cos 45° - 3 = 0$

or $R_A + R_B = 10.83\ kN.$

And

$$\Sigma M_A = 0$$

or, $5\times2 + 3\times3 + 4\cos 45° \times 4 - R_B \times 6 = 0$

or, $10 + 9 + 8\sqrt{2} - 6R_B = 0$

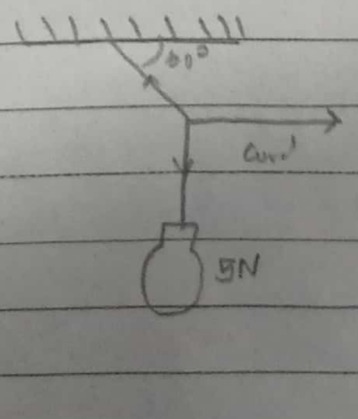
$\therefore R_B = 5.05\ kN$

Now

$R_A = (10.83 - 5.05)\ kN$

$= 5.77\ kN$

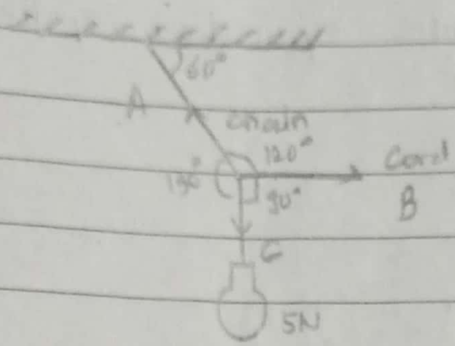
<Q.9>: A lamp weighing 5N is suspended from ceiling by a chain. It is pulled aside by a horizontal cord until the chain makes an ~~assay~~ angle of 60° with the ceiling as shown in figure. Find the tension in chain and cord applying Lami's theorem.



Date
Page

Soln.

The free body diagram;



According to Lami's theorem,

$$\frac{A}{\sin 90^\circ} = \frac{B}{\sin 130^\circ} = \frac{C}{\sin 120^\circ} \quad \text{— (i)}$$

Here, $C = 5N$.

So,

Taking ~~1st~~ last two ratios,

$$B = \frac{5 \times \sin 150^\circ}{\sin 120^\circ} \qquad \therefore B = 2.89\ N.$$

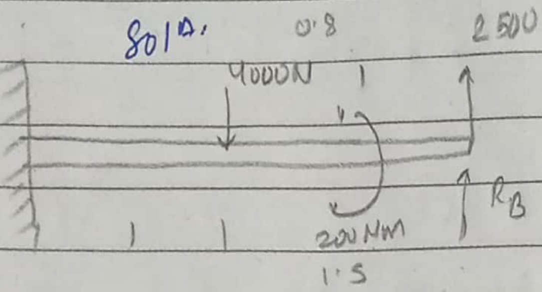
And.

$$A = \frac{B}{\sin 150^\circ} = 5.77\ N.$$

The tension on the chain is 5.77 N. and on cord is 2.89 N.

Date
Page

<10>: Two vertical forces and a moment is acting on a horizontal rod which is fixed at end at A. Determine the resultant of the system and determine equivalent system through A.



From free body diagram,

$$\Sigma F_y = 0$$

or $4000 - 2500 - R_B = 0$

$\therefore R_B = 6500$ N.

Also,

$$\Sigma M_A = 0$$

or $4000 \times 1 + 200 - 2500 \times 2.5 - R_B \times \frac{d}{\cancel{2.5}} = 0$

($\because$ Let R_B acts at d from A).

So,

$-2050 - R_B \times d = 0$

$\therefore d = 0.167$ from A.

So, resultant is at 0.167 m ~~along~~

Since single force passing through given point and A single moment.

Here, R = resultant force about A

ΣM = sum of all ~~resultant~~ moments about A.

Date ____ Page ____

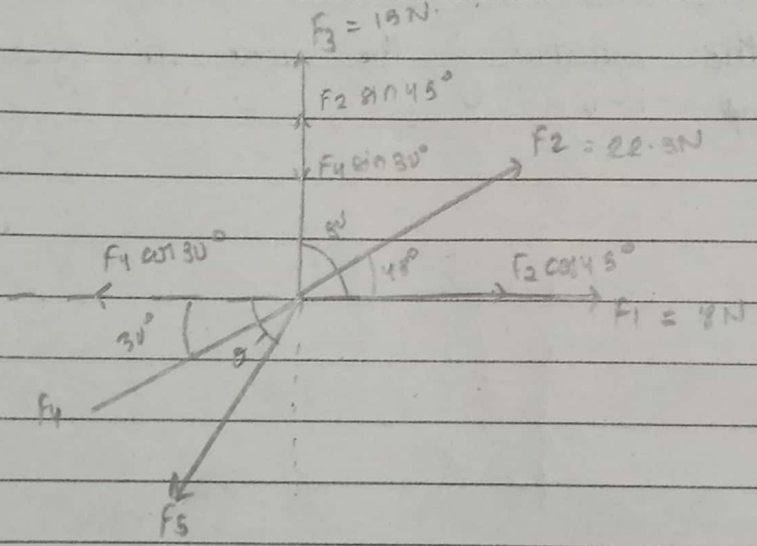
Hence,

single force = 1500 N

couple = 250 kN.

(11): Five forces are acting on equilibrium body. Find magnitude and direction of force F5.

Soln.



Here,

$F_A = 15 + F_2 \sin 45^\circ - F_4 \sin 30^\circ$

$= 15.91$ N.

$F_B = 18 + F_2 \cos 45^\circ - F_4 \cos 30^\circ$

$= 4.93$ N

Using Lami's theorem;

$$\frac{F_A}{\sin 90^\circ} = \frac{F_B}{\sin(90^\circ + \theta)} = \frac{F_5}{\sin(180^\circ - \theta)}$$

or, $F_A = \dfrac{F_B}{\cos\theta} = \dfrac{F_5}{\sin\theta}$

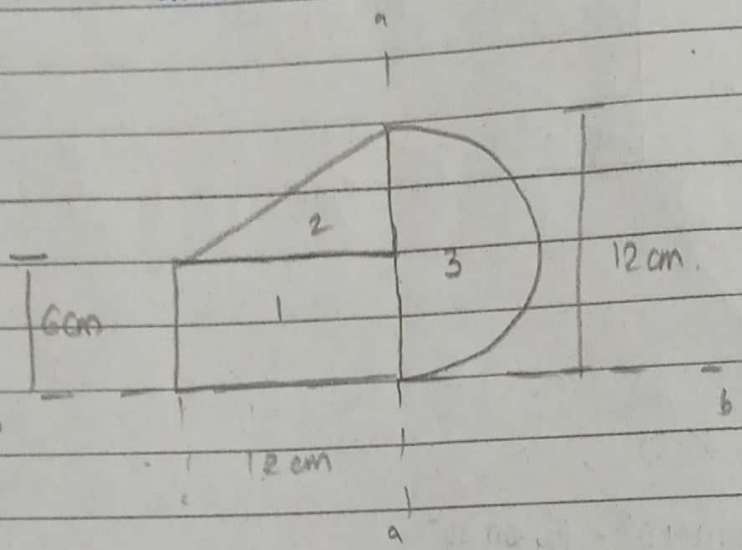
Date
Page

So,

$\cos\theta = \frac{F_B}{F_A}$ $\therefore \theta = 71.95°$

$\therefore F_5 = F_A \cdot \sin\theta$
$= 15.91 \times \sin 71.95$
$= 15.31$ N.

(12): Determine the centroid of the area in figure on axis a-a and b-b.



Soln:

Area of 1:

$A = l \times b = (6 \times 12)\,cm^2 = 72\,cm^2$

Centroid of ~~Area~~ 1: $C(x, y) = \left(\frac{12}{2}, \frac{6}{2}\right) = (6, 3)$

Date
Page

Area of 2;

$A = \frac{1}{2} \times b \times h = \frac{1}{2} \times 12 \times 6 = 36 cm^2$.

Centroid lies at b/3 and h/3.

$C(x,y) = \left(\frac{12}{3}, \frac{6}{3}\right) = (4,2)$

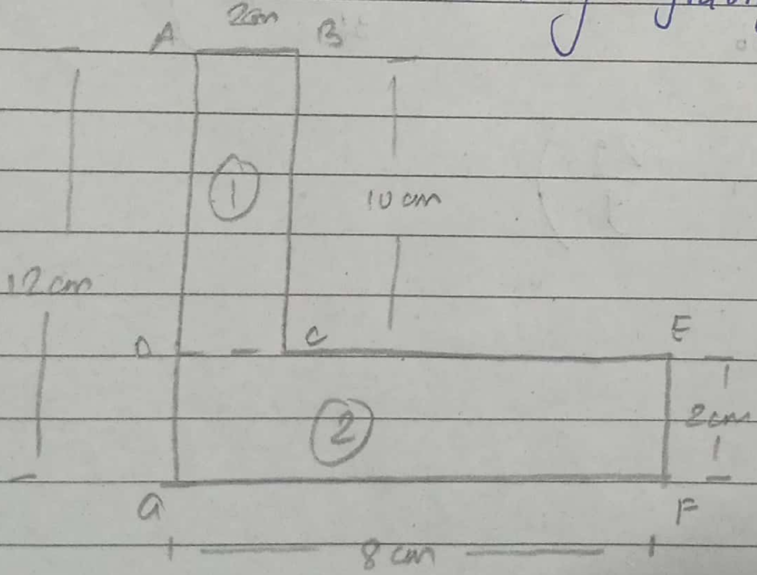
Area of 3' = $\frac{\pi R^2}{2} = \frac{\pi}{2} \times (6)^2 = 18\pi \ cm^2$.

Centroid lies at $4r/3\pi$ and r.

So,

$C(x,y) = \left(\frac{4 \times 6}{3\pi}, 6\right) = \left(\frac{8}{3\pi}, 6\right)$

(13): Determine the centre of gravity.



Date
Page

Area of rect 1;

$A_1 = 10\,cm \times 2\,cm$

$= 20\,cm^2$

Centroid $= \left(\frac{2}{2}, \frac{10}{2}\right) = (1, 5)$

$A_2 = 8 \times 2\,cm^2 = 16\,cm^2$

Centroid $= \left(\frac{8}{2}, \frac{2}{2}\right) = (4, 1)$

$$CG(x, y) = \left(\frac{a_1x_1 + a_2x_2}{a_1 + a_2}, \frac{a_2y_2 + a_1y_1}{a_1 + a_2}\right)$$

$$= \left(\frac{20 \times 1 + 16 \times 4}{36}, \frac{16 \times 1 + 20 \times 5}{36}\right)$$

$$= \left(\frac{7}{3}, \frac{29}{9}\right)$$

Date
Page

(14): ~~Determine~~ A steel column is 3m long and 0.4 diameter, it carries a load of 50 MN. Given that modulus of elasticity is 200 GPa, Calculate the compressive stress and strain and determine the depression of column.

Soln:

Given,

$L = 3m = 3000\ mm$

$d = 0.4\ m = 0.4 \times 10^3\ mm$

$F = 50MN = 50 \times 10^6\ N$

$E = 200GPa = 200 \times 10^3\ MPa =$

Now,

$$\sigma_c = \frac{F}{A} = \frac{50 \times 10^6\ N}{\frac{\pi d^2}{4}} = \frac{50 \times 10^6}{\frac{\pi \times 400^2}{4}} = 397.88\ MPa.$$

$$\varepsilon_c = \frac{\sigma_c}{E} = \frac{397.88}{200 \times 10^3} = 1.98 \times 10^{-3}$$

$$\delta = \frac{FL}{EA} = \frac{50 \times 10^6 \times 3000}{200 \times 10^3 \times \frac{\pi}{4} \times 400^2} = 5.96\ mm.$$