



University of Technology
Building and Construction Engineering Department
Final Examination - First Attempt - 2013-2014



Subject : Engineering Mechanics
Class: 1st (All Branches)

Date: 1 / 6 /2014
Time: 3 hr.

Note: Answer FIVE questions only.

Q1/ For the force system shown in Fig.(1), if the resultant of the force system is a couple (991 N.cm) clockwise determine the value of forces (p) and (Q).

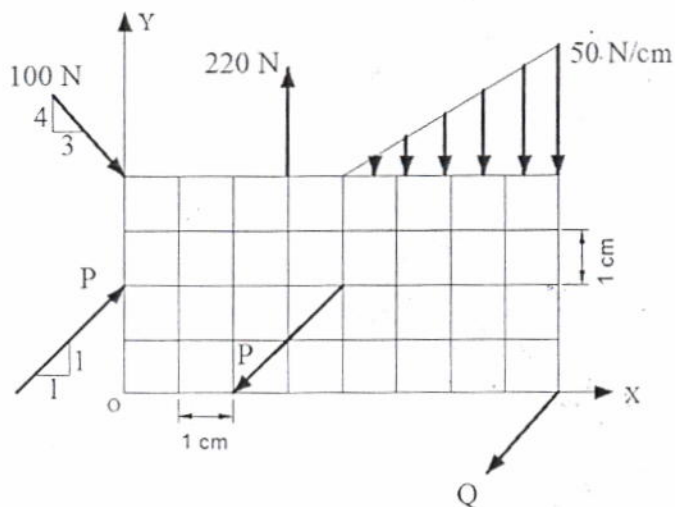


Fig. (1)

Q2/ Determine the reactions at A and B For the force loaded shown in Fig. (2).

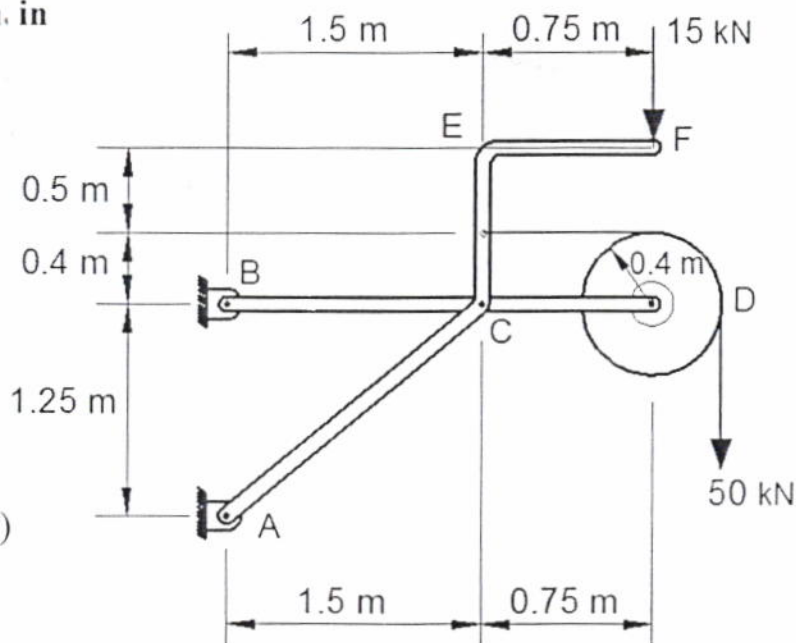


Fig. (2)

Q3/ The (20 N) homogeneous bar AB rests on block C as shown in Fig. (3). The coefficient of friction for both sliding surfaces is (0.35). Determine the weight of the block C which will cause impending motion.

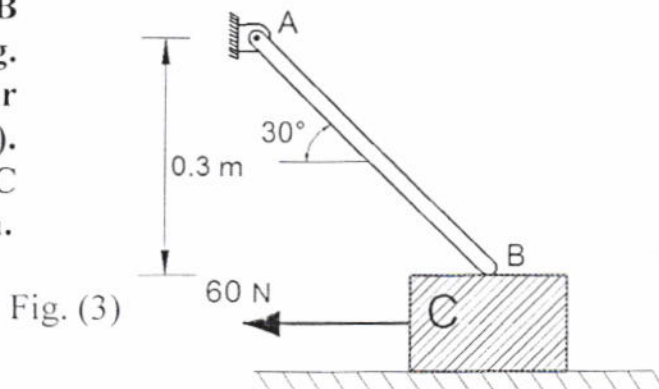


Fig. (3)

- Q4/ For the truss shown in Fig. (4), Determine the forces in the members (cd, ef, df and de) .

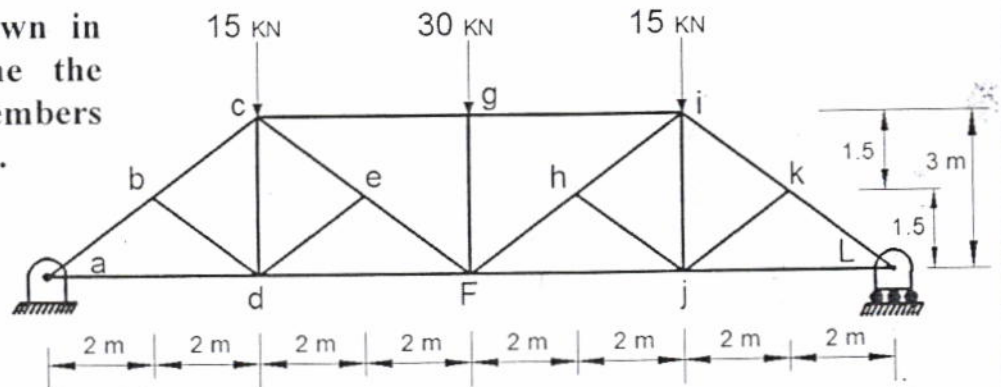


Fig. (4)

- Q5/ For the shaded area shown in Fig.(5), Determine

- The coordinates of the centroid for the shaded area.
- The moment of inertia with respect to x- axis.

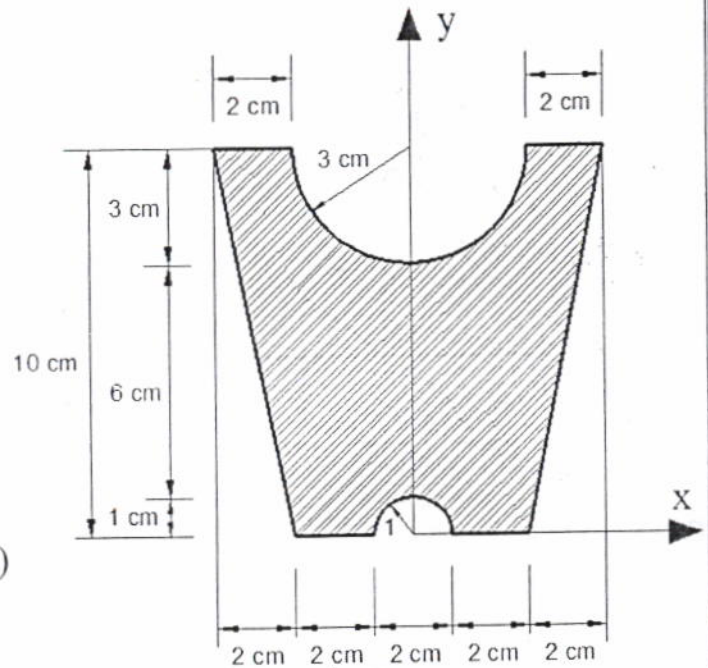


Fig. (5)

- Q6/ (A): A particle moves along a horizontal line ; it starts from point A with a velocity of (6 m/sec.) to the right and an acceleration of (4 m/sec².) to the right and travels for (3 sec.), then the acceleration changes to (5 m/sec².) to the left for (4 sec.). At the end of this time, the particle travels for (6 sec.) with a constant velocity .

- Determine the position of the particle with reference to point A at the end of the last (6 sec.) interval.
- Determine the total distance traveled.

- (B): For the shaded area shown in Fig.(6), determine The product of inertia with respect to axes through origin.

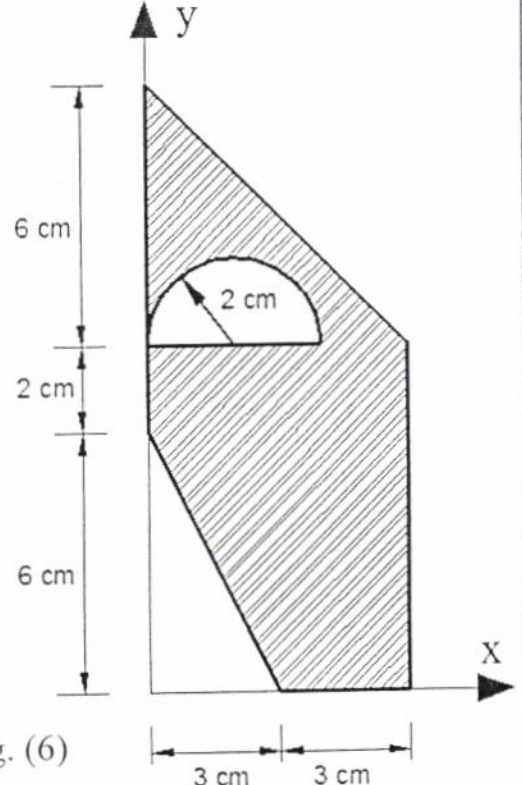
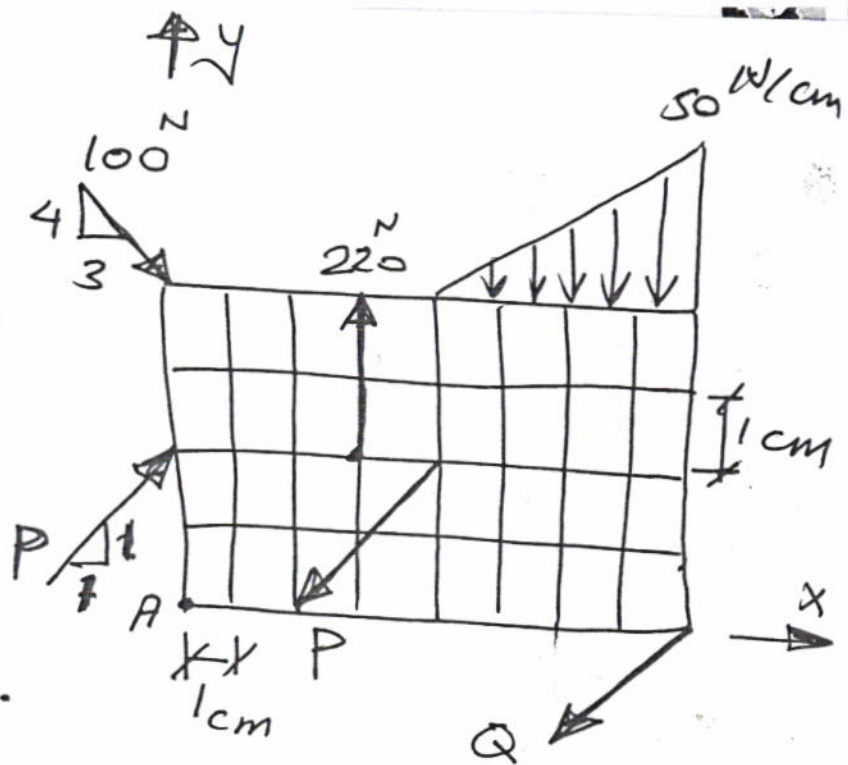


Fig. (6)

For the force system shown in fig. (), if the resultant of the force system is a couple (991 N.cm) clockwise determine the value of forces (P) & (Q).



Solution: Resultant is a couple $\therefore R_x = R_y = 0$

$$R_x = 0 = \sum F_x \rightarrow +$$

$$100 \times \frac{3}{5} - Q_x = 0$$

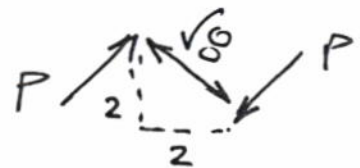
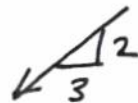
$$\therefore Q_x = 60 \text{ N} \leftarrow$$

$$R_y = 0 = \sum F_y \uparrow +$$

$$220 - Q_y - 100 \times \frac{4}{5} - \frac{50 \times 4}{2} = 0$$

$$\therefore Q_y = 40 \text{ N} \downarrow$$

$$Q = \sqrt{60^2 + 40^2} = 72.11 \text{ N}$$



$$\sum M_A^+ \leftarrow = 100 \times 4 \times \frac{3}{5} - 220 \times 3 + \sqrt{8}P$$

$$+ \frac{50 \times 4}{2} \times \left(\frac{2}{3} \times 4 + 4 \right) + 40 \times 8$$

$$991 = 240 - 660 + 2.828P + 666.667 + 320$$

$$991 = 566.667 + 2.828P$$

$$\therefore P = 150 \text{ N.}$$

Q2:

$$\sum M_A = 0 \quad \curvearrowright$$

$$\begin{aligned} -15 \times 2.25 - 50 \times 2.65 \\ + B_x \times 1.25 &= 0 \\ \therefore B_x &= 133 \text{ kN} \leftarrow \end{aligned}$$

$$\sum F_x = 0 \quad \rightarrow \quad A_x = 133 \rightarrow$$

$$\sum F_y = 0 \quad \uparrow$$

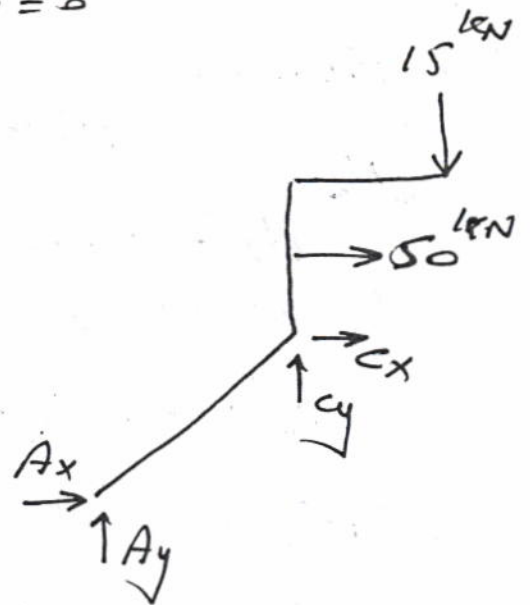
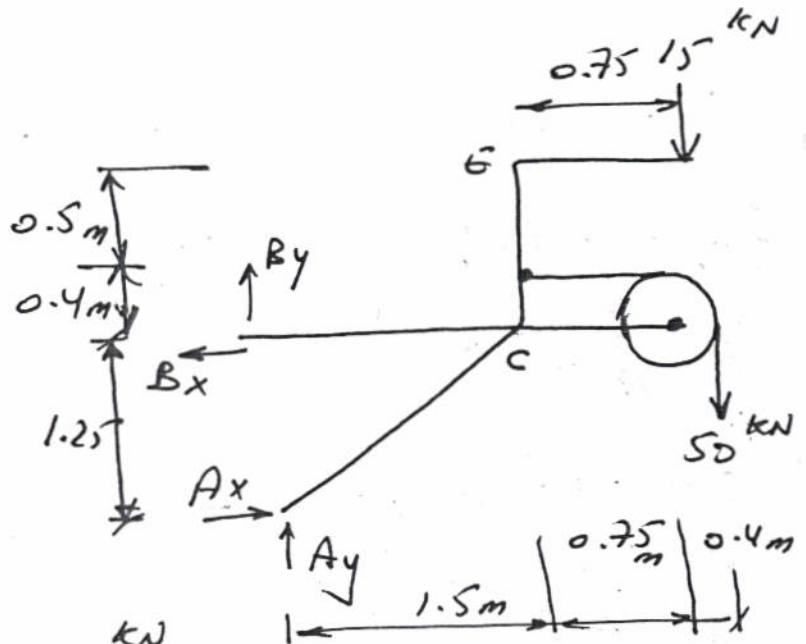
$$\begin{aligned} -15 - 50 + A_y + B_y &= 0 \\ \therefore B_y &= 65 - A_y \end{aligned}$$

$$\sum M_C = 0 \quad \curvearrowright$$

$$\begin{aligned} -15 \times 0.75 - 50 \times 1.15 \\ + 133 \times 1.25 - A_y \times 1.5 &= 0 \end{aligned}$$

$$\therefore A_y = 65 \text{ kN} \uparrow$$

$$\therefore B_y = 65 - 65 = 0$$



Q3:

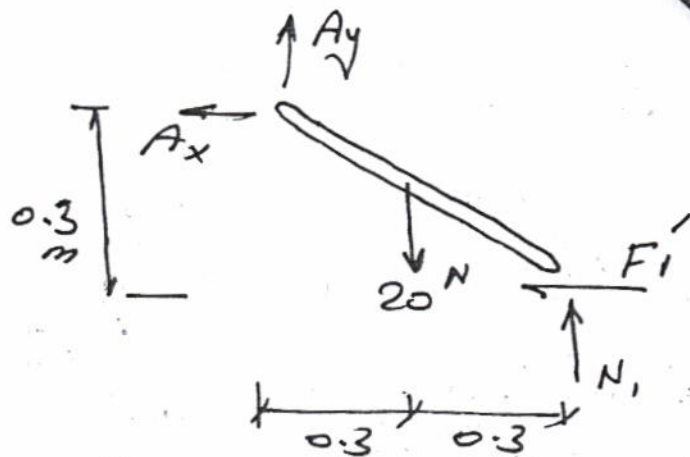
$$F_1' = 0.35 N_1$$

$$\sum M_A = 0 \quad \curvearrowright$$

$$-20 \times 0.3 + N_1 \times 0.6 - 0.35 N_1 \times 0.3 = 0$$

$$\therefore N_1 = 12.12 \text{ N} \quad \uparrow$$

$$\therefore F_1' = 4.24 \text{ N} \quad \leftarrow$$



F.B.D. ①

F.B.D. ②

$$\sum F_y = 0 \quad \uparrow \oplus$$

$\frac{W}{2}$

$$N_2 - W - 12.12 = 0$$

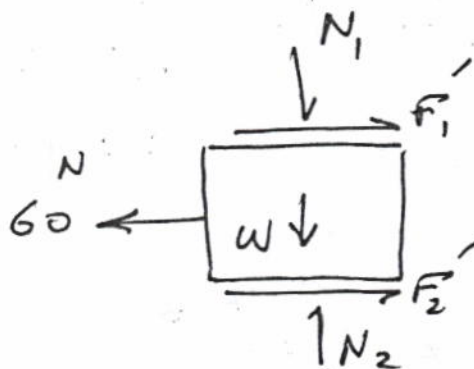
$$\therefore N_2 = W + 12.12$$

$$F_2' = 0.35(W + 12.12)$$

$$\sum F_x = 0 \quad \rightarrow +$$

$$4.24 + 0.35(W + 12.12) - 60 = 0$$

$$W = 147.2 \text{ N}$$



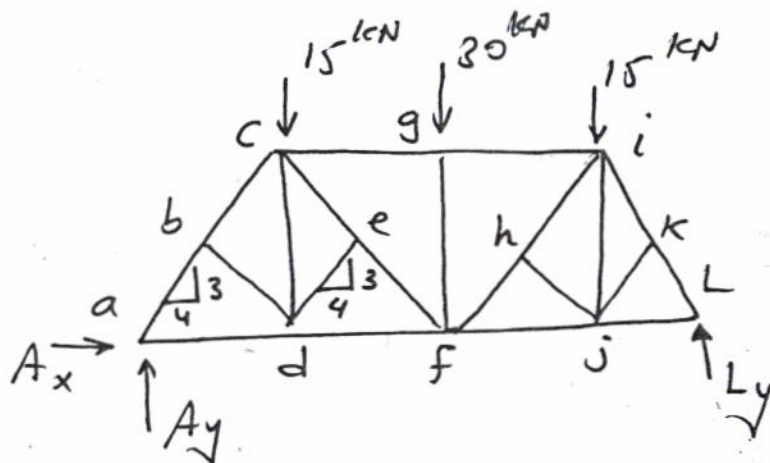
F.B.D. ②

Q4:

from symm.

$$A_y = L_y = 30 \text{ kN}$$

$$A_x = 0 \quad (\sum F_x = 0)$$



$$\text{member } cd = 0 = bd = 0$$

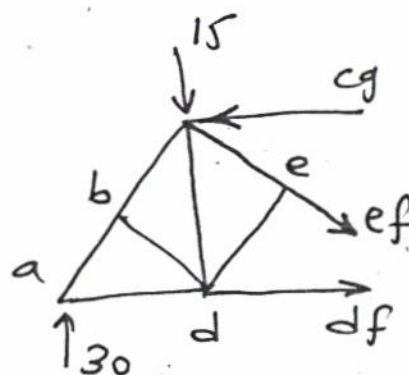
$$\sum M_f = 0 \quad \curvearrowright$$

$$-30 \times 8 + 15 \times 4 + C_g \times 3 = 0$$

$$\therefore C_g = 60 \text{ kN comp.}$$

$$\sum F_x = 0 \rightarrow P = df - 60 + 25 \times \frac{4}{5}$$

$$\therefore df = 40 \text{ tension}$$



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

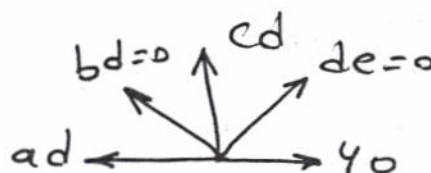
$$30 - 15 - ef \times \frac{3}{5} = 0$$

$$\therefore ef = \frac{15}{5-3} = 25 \text{ kN tension}$$

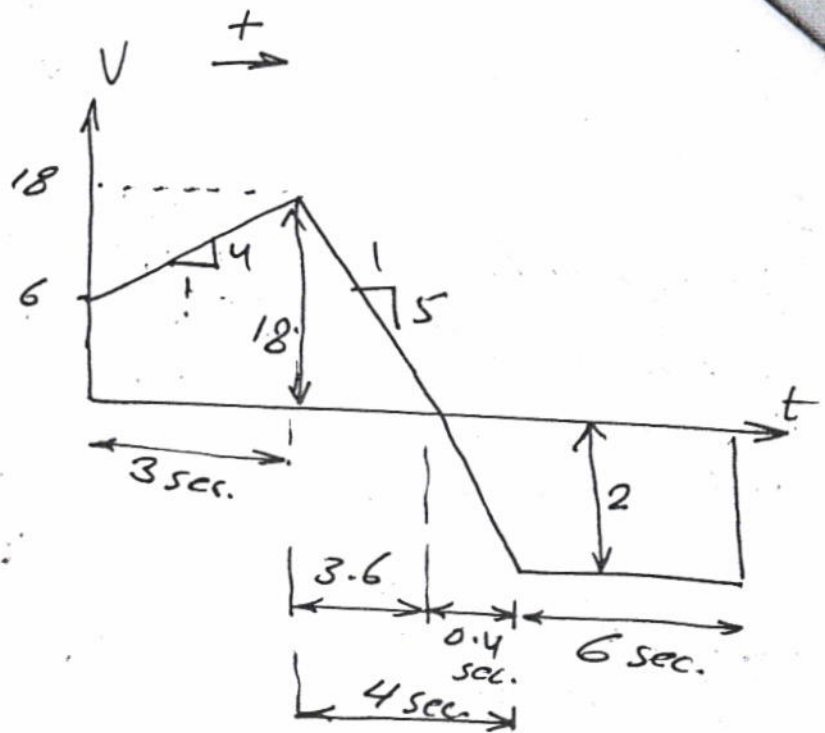
Joint d

$$\sum F_y = 0$$

$$\therefore cd = 0$$



Q6: (a)



$$a = \frac{V_f - V_i}{\Delta t}$$

$$4 = \frac{V_f - 6}{3}$$

$$\therefore V_f = 18 \text{ m/sec.}$$

$$-5 = \frac{V_f - 18}{4}$$

$$V_f = -20 + 18 = -2 \text{ m/sec.}$$

$$t_1 = \frac{18}{5} = 3.6 \text{ sec.}$$

$$Q = \frac{6+18}{2} \times 3 + \frac{18 \times 3.6}{2} - \frac{2 \times 0.4}{2} - 2 \times 6$$

$$= 56 \text{ m to the right of A.}$$

$$Q = \frac{6+18}{2} \times 3 + \frac{18 \times 3.6}{2} + \frac{2 \times 0.4}{2} + 2 \times 6 = 80.8 \text{ m.}$$

Q6: (B)

$$I_{xy①} = I_{x'y'} + A\bar{x}\bar{y}$$

$$= (6 \times 8)(3)(4) = 576 \text{ cm}^4$$

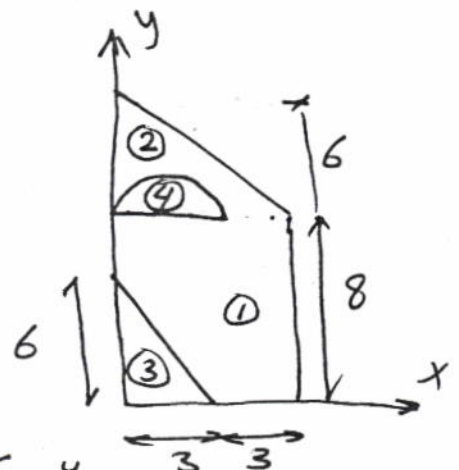
$$I_{xy②} = -\frac{(6^2)(6)^2}{72} + \frac{(6 \times 6)(2)(8+2)}{2}$$

$$= 342 \text{ cm}^4$$

$$I_{xy③} = -\frac{(3)^2(6)^2}{72} + \frac{3 \times 6(1)(2)}{2} = 13.5 \text{ cm}^4$$

$$I_{xy④} = I_{x'y'} + \left(\frac{2^2\pi}{2}\right)(2)\left(8 + \frac{4 \times 2}{3\pi}\right) = 111.15 \text{ cm}^4$$

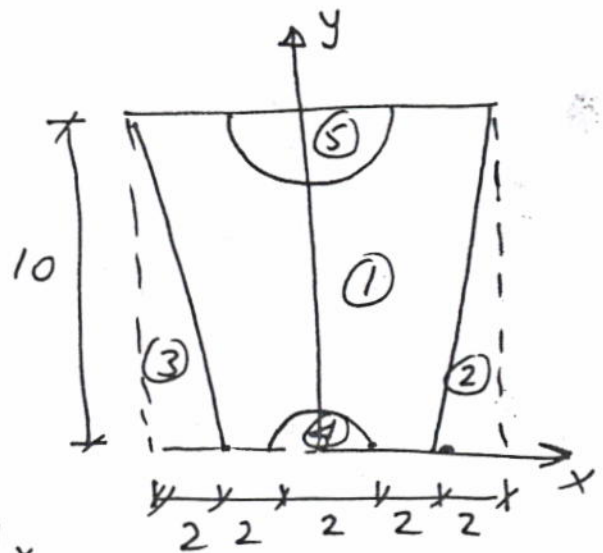
$$\therefore I_{xy} = 576 + 342 - 13.5 - 111.15 = \underline{\underline{793.35 \text{ cm}^4}}$$



Q5:

a. centroid:

$\bar{x} = 0$ from symm.



area.

\bar{y}

M_x

1) 10×10
 $= 100$

5

500

2) $-\frac{10 \times 2}{2} = -10$

$\frac{10}{3}$

-33.33

-10

$\frac{10}{3}$

-33.33

3) $-\frac{1^2 \pi}{2} = -1.5708$

$\frac{4r}{3\pi} = 0.424$

-0.666

4) $-\frac{3^2 \pi}{2} = -14.137$

$(10 - \frac{4r}{3\pi}) \cdot$
 $= 8.726$

-123.36

$\Sigma A = 64.292$

$\Sigma M = 309.314$

$\therefore \bar{y} = \frac{309.314}{64.292} = 4.81 \text{ cm.}$

b. Moment of inertia.

$I_{x(1)} = \frac{bh^3}{3} = \frac{10 \times 10^3}{3} = 3333.33 \text{ cm}^4$

$I_{x(2)} = \frac{bh^3}{12} \times 2 = \frac{2 \times 10^3}{12} \times 2 = 333.33 \text{ cm}^4$

$I_{x(4)} = \frac{\pi R^4}{8} = 0.3927$

$I_{x(5)} : I_{C_{x_5}} = \frac{\pi R^4}{8} - \frac{3^2 \pi}{2} \left(\frac{4 \times 3}{3\pi} \right)^2 = 8.89 \text{ cm}^4$

$I_{x(5)} = 8.89 + \frac{3^2 \pi}{2} \left(10 - \frac{4 \times 3}{3\pi} \right)^2 = 1085.525 \text{ cm}^4$

$I_x = I_{x(1)} - I_{x(2)} - I_{x(3)} - I_{x(4)} - I_{x(5)} = \underline{1914.08 \text{ cm}^4}$