



University of Technology  
Building and Construction Engineering Department  
Final Exam. - First Attempt - 2012-2013



Subject :Engineering Mechanics  
Class: 1<sup>st</sup> (All Branches)

Date: 9 / 6 /2013  
Time: 3 hrs.

2

Note: Answer FIVE questions only.

Q1/ Determine the resultant of the force system shown in Fig. (1), and show it on a sketch.

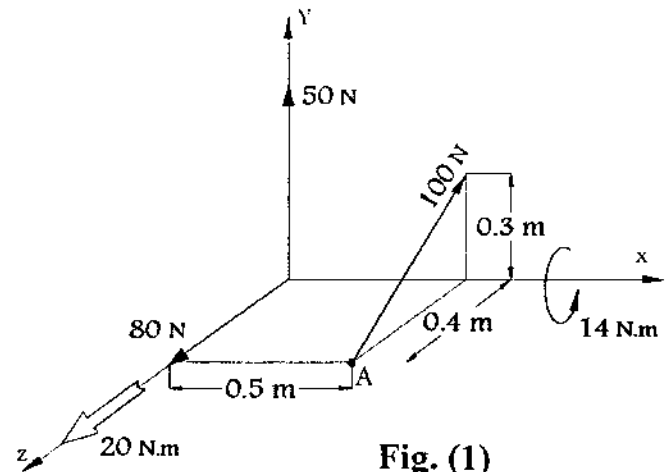


Fig. (1)

Q2/ Determine the reactions at B, E, and F For the frame loaded as shown in Fig. (2).

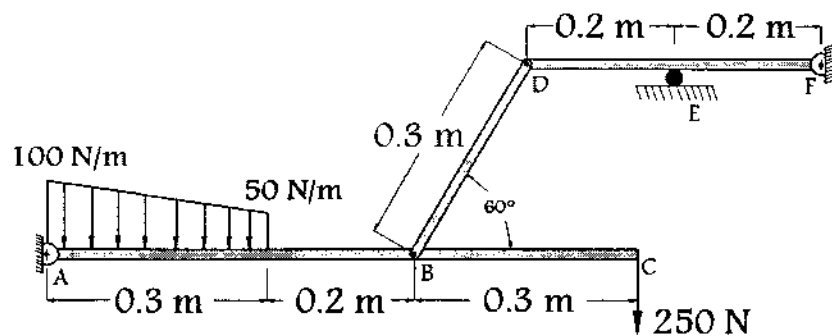


Fig. (2)

Q3/ The compound beam shown in Fig. (3) is adjusted into the horizontal position by means of a wedge located at it's right support. If the coefficient of friction between the wedge and the surfaces of contact is ( $\mu=0.25$ ), determine the horizontal force (P) which will cause impending motion of the wedge.

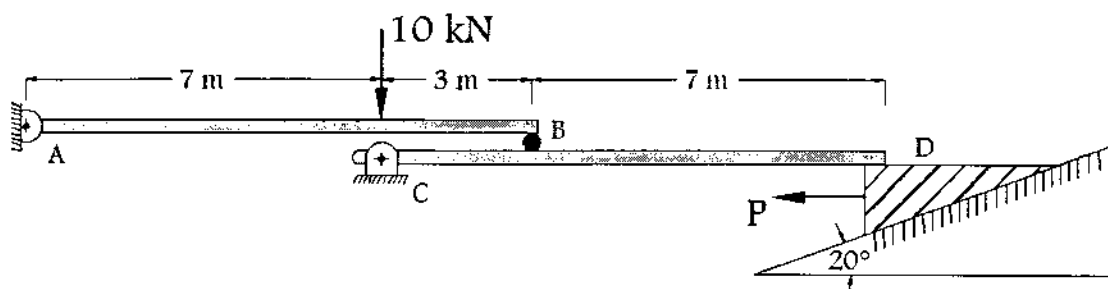
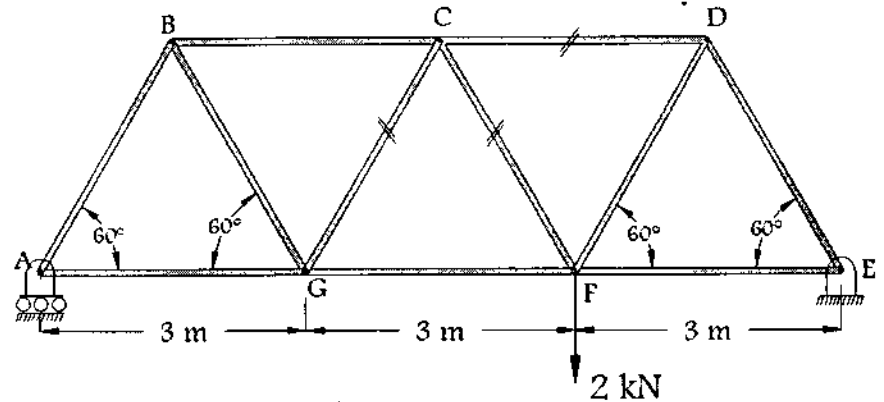


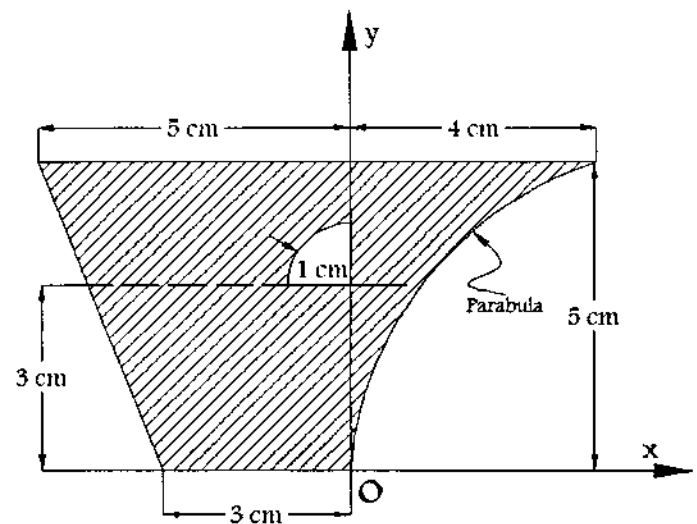
Fig. (3)

**Q4/ Determine the forces in the members GC , CD and CF for the truss shown in Fig. (4).**



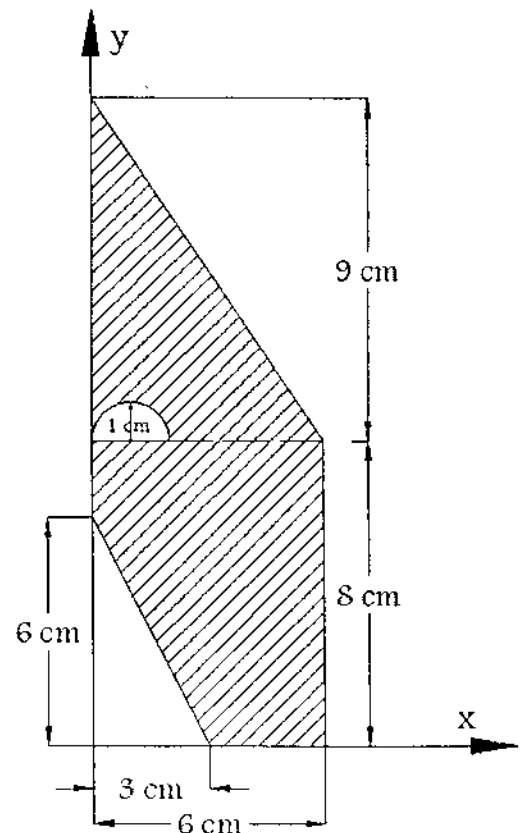
**Fig. (4)**

**Q5/ Determine the coordinates of the centroid for the shaded area shown in Fig. (5).**



**Fig. (5)**

**Q6/ For the shaded area shown in Fig.(6), determine:**  
 a- The moment of inertia with respect to x- axis.  
 b- The product of inertia with respect to axes through origin.



**Fig. (6)**

⑦ الإجابة النموذجية لأسئلة المحاضرات الأولى  
المرحلة الأولى / الدور الأول / العام الدراسي 2012-2013

Q.1

Resolve  $F_1$  to its rectangular components

$$F_{1y} = 100 \times \frac{3}{5} = 60 \text{ N} \quad \uparrow A$$

$$F_{1z} = 100 \times \frac{4}{5} = 80 \text{ N} \quad \nearrow A$$

⊕

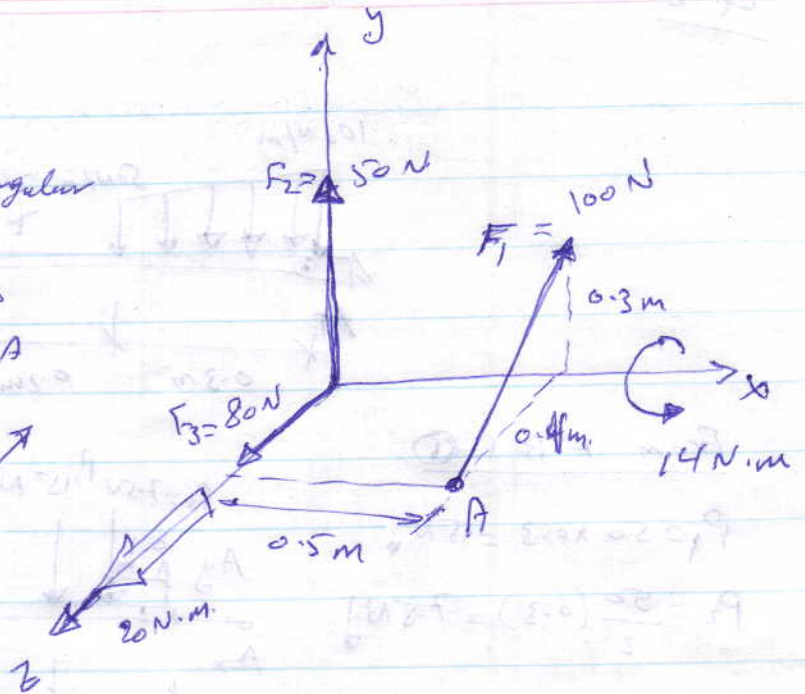
$$R_x = \sum F_x$$

$$R_x = 0$$

$$\uparrow \uparrow R_y = \sum F_y \Rightarrow R_y = 60 + 50 = 110 \text{ N} \quad \uparrow$$

$$R_z = \sum F_z \Rightarrow R_z = 80 - 80 = 0$$

$$\therefore R = 110 \text{ N} \quad \uparrow$$



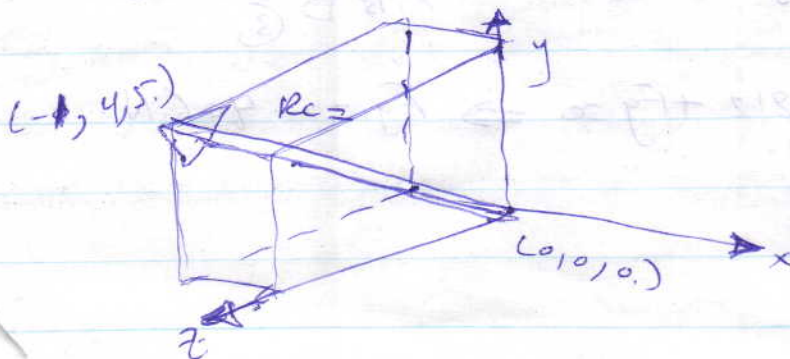
$$\begin{aligned} \textcircled{1} \quad \sum M_x &= -14 + 60(0.4) = 10 \text{ N.m} \quad \Rightarrow C_x = 10 \text{ N.m} \\ \textcircled{2} \quad \sum M_y &= -80(0.5) = -40 = 40 \text{ N.m} \quad \Rightarrow C_y = 40 \text{ N.m} \\ \textcircled{3} \quad \sum M_z &= -20 - 60(0.5) = -50 \Rightarrow \sum M_z = 50 \text{ N.m} \end{aligned}$$

$$C_z = 50 \text{ N.m}$$

$$R_c = \sqrt{C_x^2 + C_y^2 + C_z^2} = \sqrt{(10)^2 + (40)^2 + (50)^2} = 64.81 \text{ N} \quad \text{from } (0, 0, 0)$$

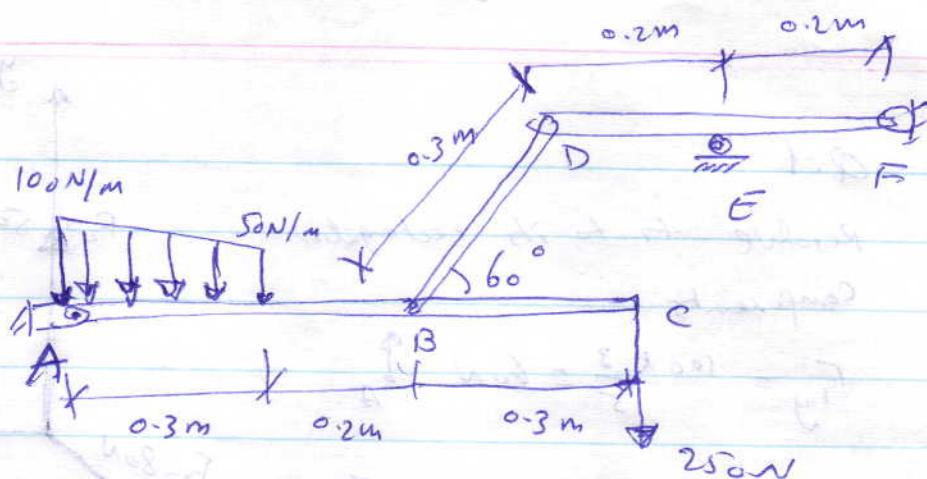
through  $(-1, 4, 5)$

$\therefore$  The resultant is a force and couple





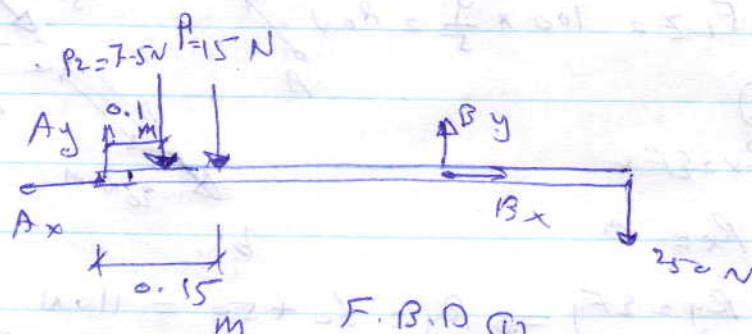
Q-2



From F.B.D ①

$$P_1 = 50 \times 0.3 = 15 \text{ N} \downarrow$$

$$P_2 = \frac{50}{2} (0.3) = 7.5 \text{ N} \downarrow$$



$$\sum M_A = 0 \quad (+\circlearrowleft)$$

$$250(0.8) - B_y(0.5) + 15(0.15) + 7.5(0.1) = 0$$

$$B_y = 406 \text{ N} \uparrow \text{ on } ABC$$

From F.B.D ②

$$(+\uparrow) \sum F_{y20} \Rightarrow D_y = 406 \text{ N} \uparrow \text{ on } DB$$

$$(+\circlearrowleft) \sum M_D = 0 \Rightarrow -406(0.3 \cos 60^\circ) + B_x(0.3 \sin 60^\circ) = 0$$

$$B_x = -60.4 + 0.26 B_x = 0$$

$$\therefore B_x = 234.2 \text{ N} \leftarrow \text{on } BD$$

$$B_x = 234.2 \text{ N} \rightarrow \text{on } ABC$$

$$D_x = 234.2 \text{ N} \rightarrow \text{on } BD$$

$$D_x = 234.2 \text{ N} \leftarrow \text{on } DEF$$

From F.B.D ③

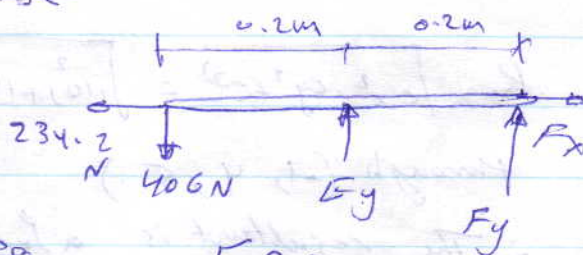
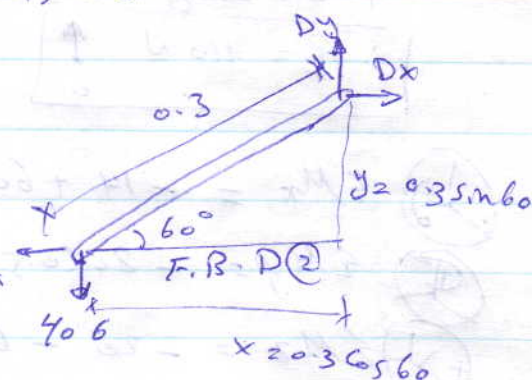
$$(+\rightarrow) \sum F_{x20} \Rightarrow F_x = 234.2 \text{ N} \rightarrow$$

$$(+\circlearrowleft) \sum M_{F20} \Rightarrow -406(0.4) + F_y(0.2) = 0$$

$$F_y = 812 \text{ N} \uparrow$$

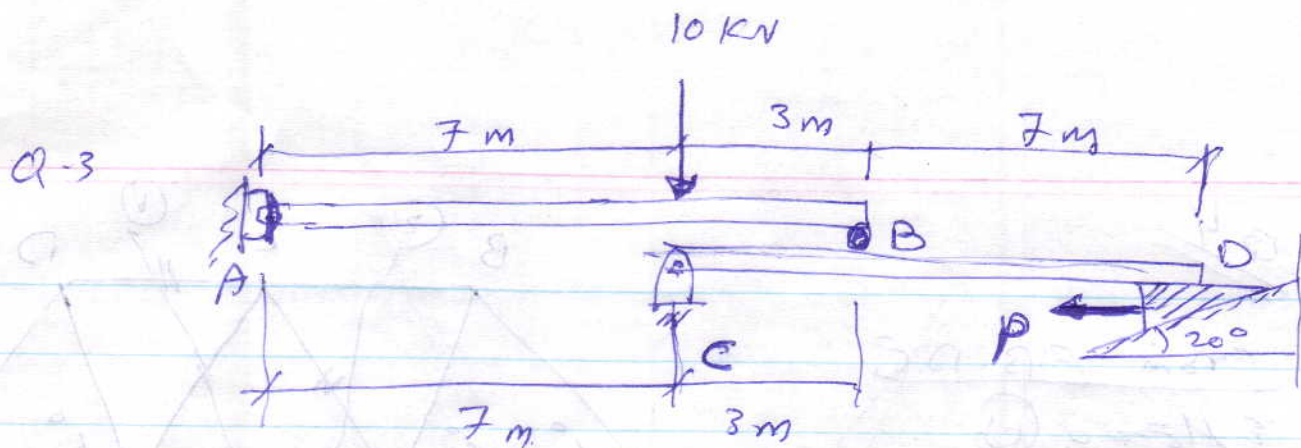
$$(+\uparrow) \sum F_{y20} \Rightarrow -406 + 812 + F_y = 0 \Rightarrow F_y = -406 \text{ N}$$

$$\therefore F_y = 406 \text{ N} \downarrow$$



F.B.D. ③





From F.B.D ①

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

$$A_x = 0$$

$$\sum M_A = 0 \quad (+)$$

$$10(7) - B_y(10) = 0$$

$$B_y = 7 \text{ kN} \uparrow \text{ on AB}$$

From F.B.D ②

$$\sum M_C = 0 \quad (+)$$

$$7(3) - N_1(10) = 0$$

$$N_1 = 2.1 \text{ kN} \uparrow \text{ on CD}$$

$$F_1' = 0.25(2.1) = 0.525 \text{ N} \leftarrow$$

$$N_1 = 2.1 \text{ kN} \downarrow \text{ on wedge}$$

From F.B.D ③

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

$$-2.1 + N_2 \cos 20^\circ + 0.25 N_2 \sin 20^\circ = 0$$

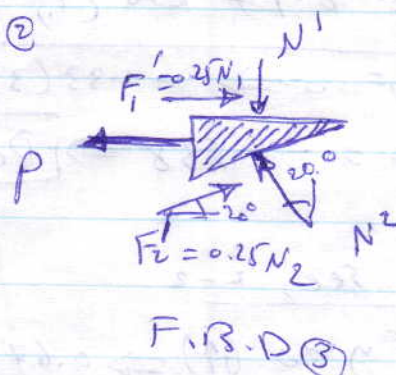
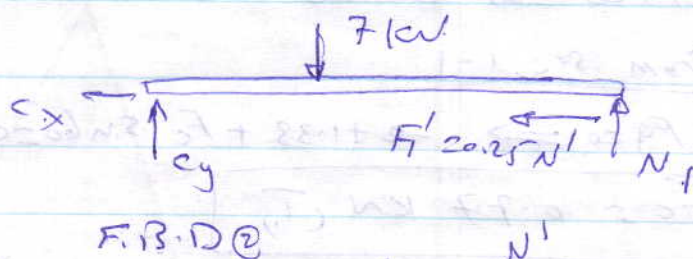
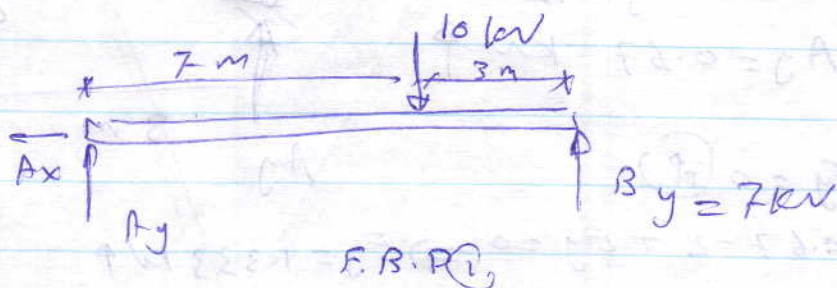
$$\therefore -2.1 + 0.94 N_2 + 0.086 N_2 = 0$$

$$N_2 = 2.05 \text{ kN}$$

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

$$0.525 - P - 2.05 \sin 20^\circ + 0.25(2.05) \cos 20^\circ = 0$$

$$P = 0.31 \text{ kN} \leftarrow$$





or

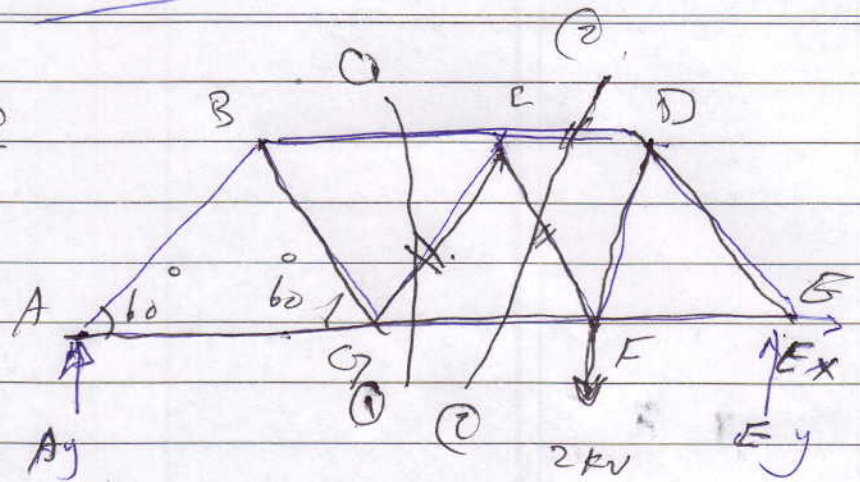
Q.4

From F.B.D. of truss

$$\sum M_E = 0 \quad (+\circlearrowleft)$$

$$A_y \times 9 - 2 \times 3 = 0$$

$$A_y = 0.67 \text{ kN}$$

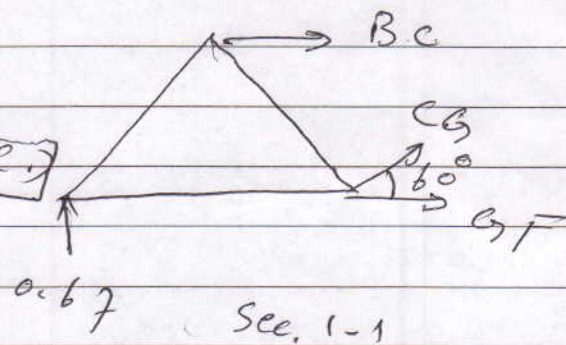


From Sec. 1-1

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

$$CG \sin 60 + 0.67 = 0$$

$$CG = -0.77 = 0.77 \text{ kN (C)}$$

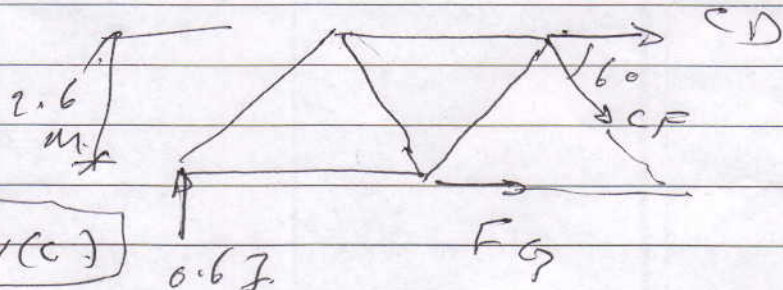


From Sec. 2-2

$$(+\circlearrowleft) \sum M_F = 0$$

$$CD \times 2.6 + 0.67 \times 6 = 0$$

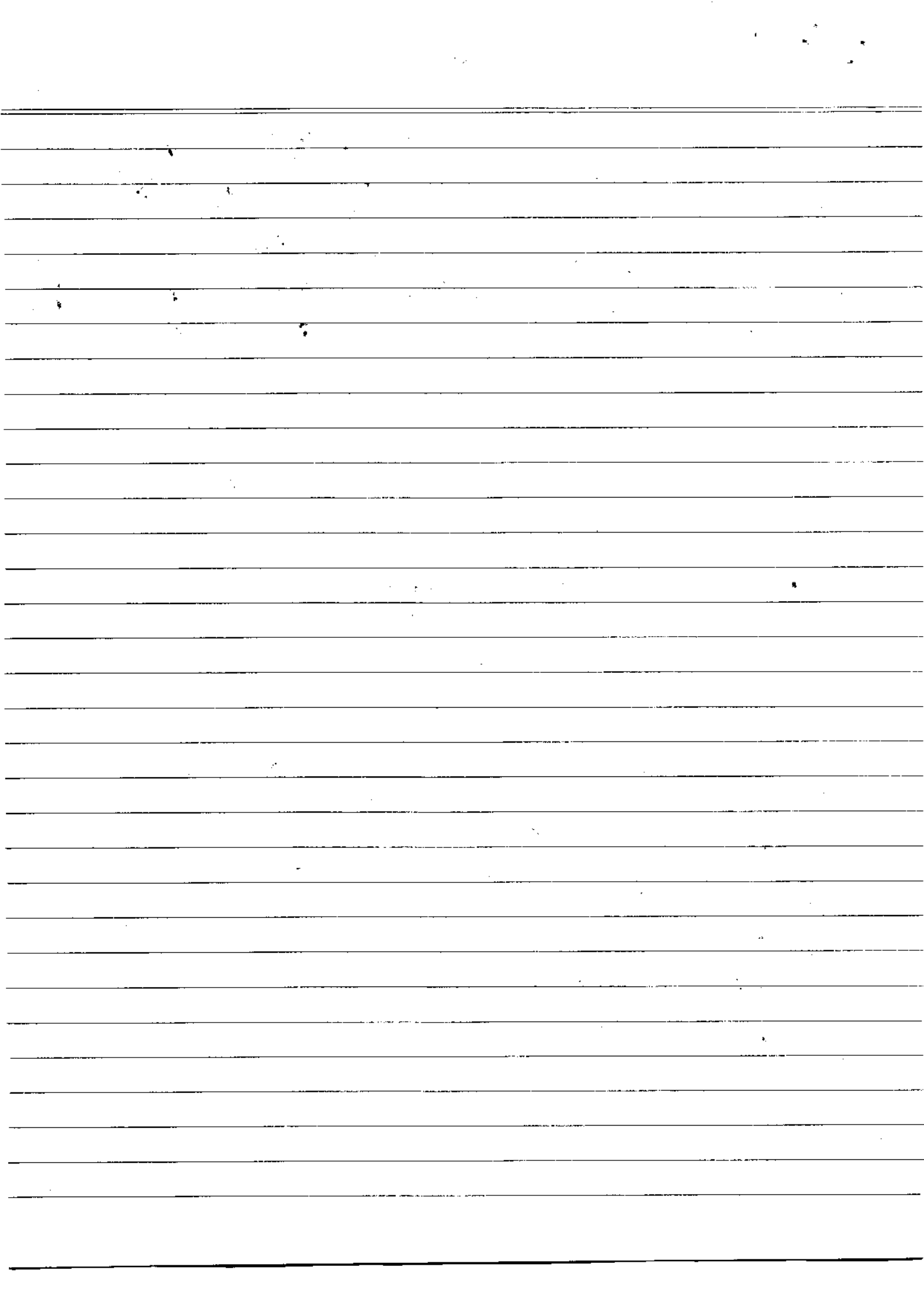
$$CD = -1.5 = 1.5 \text{ kN (C)}$$



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

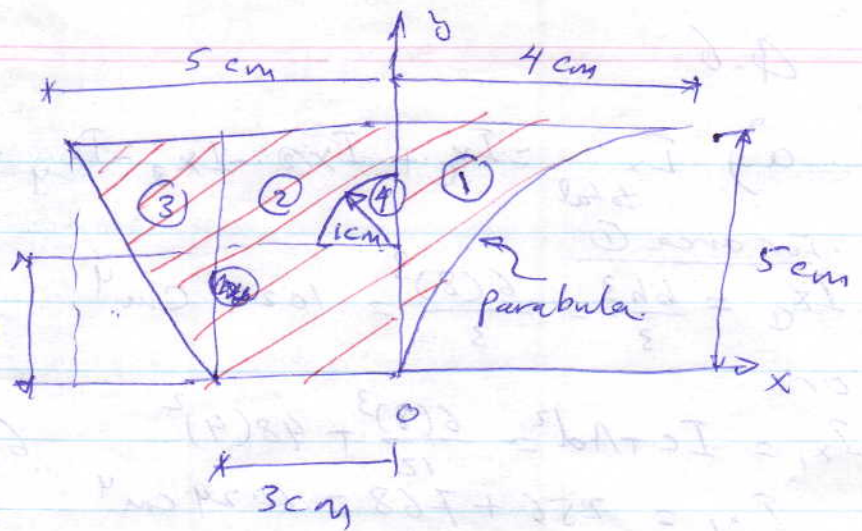
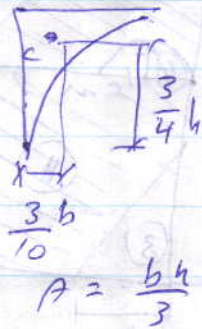
$$-CF \sin 60 + 0.67 = 0$$



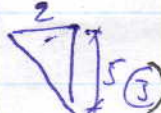
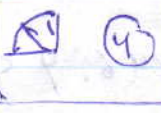
$$CF = 0.77 \text{ kN (T)}$$





Q.5



Symbol	Area cm <sup>2</sup>	x coord. cm	My cm <sup>3</sup>	y coord. cm	Mx cm <sup>3</sup>
 ①	$\frac{5 \times 4}{3} = 6.67$	$\frac{3}{10} \times 4 = 1.2$	8	$\frac{3}{4}(5) = 3.75$	25
 ②	15	-1.5	-22.5	2.5	37.5
 ③	$\frac{2 \times 5}{2} = 5$	$-\left[\frac{1}{3} + 3\right] = -3.67$	-18.35	$\frac{10}{3} = 3.33$	16.67
 ④	$\left[\frac{(1)^2 \pi}{4}\right] = -0.786$	$\left[\frac{4(1)}{3\pi} = 0.425\right]$	0.334	$3 + \frac{4(1)}{3\pi} = 3.425$	-2.69
Total	25.88		-3.2		76.48

$$\bar{x} = \frac{My_T}{A_{total}} = \frac{-3.2}{25.88} = -1.46 \text{ cm}$$

$$\bar{y} = \frac{Mx_{total}}{A_{total}} = \frac{76.48}{25.88} = 2.96 \text{ cm}$$



Q.6

$$a) \bar{I}_{x_{total}} = \bar{I}_{x_1} + \bar{I}_{x_2} - \bar{I}_{x_3} - \bar{I}_{x_4}$$

For area ①

$$\bar{I}_{x_1} = \frac{bh^3}{3} = \frac{6(8)^3}{3} = 1024 \text{ cm}^4$$

or

$$\bar{I}_{x_1} = I_c + Ad^2 = \frac{6(8)^3}{12} + 48(4)^2$$

$$\bar{I}_{x_1} = 256 + 768 = 1024 \text{ cm}^4$$

For area ②

$$\bar{I}_{x_2} = \frac{6(9)^3}{36} + \frac{6 \times 9}{2} (11)^2 = 121.5 + 3267$$

$$\bar{I}_{x_2} = 3388.5 \text{ cm}^4$$

For area ③

$$\bar{I}_{x_3} = \frac{3 \times 6^3}{12} = 54 \text{ cm}^4$$

$$\text{or } \bar{I}_{x_3} = \frac{3 \times 6^3}{36} + \left( \frac{3 \times 6}{2} \right) (2)^2 = 18 + 36 = 54 \text{ cm}^4$$

For area ④

$$\bar{I}_{x_4} = 0.11(1)^4 + \frac{(1)^2 \pi}{9} \left[ 8 + \frac{4(1)}{3\pi} \right]^2$$

$$= 0.11 + 1.571(8.425)^2 = 111.62 \text{ cm}^4$$

$$\bar{I}_{x_{total}} = 1024 + 3388.5 - 54 - 111.62 = 4246.9 \text{ cm}^4$$

$$b) \bar{I}_{xy_{total}} = \bar{I}_{xy_1} + \bar{I}_{xy_2} - \bar{I}_{xy_3} - \bar{I}_{xy_4}$$

For area ①

$$\bar{I}_{xy_1} = \bar{I}_{xy'_1} + A \bar{x} \bar{y} = (8 \times 6)(-3)(4) = -576 \text{ cm}^4$$

For area ②

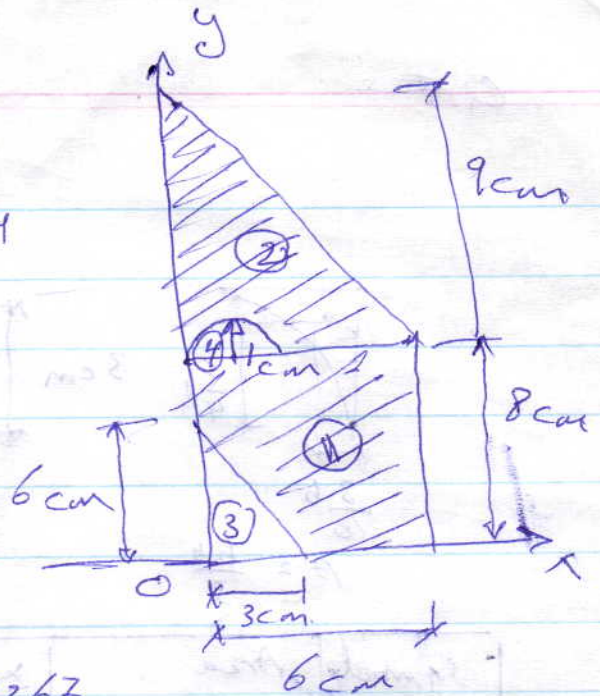
$$\bar{I}_{xy_2} = \frac{-(6)^2(9)^2}{72} + \frac{6 \times 9}{2} (2)(11) = -40.5 + 594$$

$$\bar{I}_{xy_2} = 553.5 \text{ cm}^4$$

For area ③

$$\bar{I}_{xy_3} = \frac{-(3)(6)^2}{72} + \frac{3 \times 6}{2} (1)(2) = -4.5 + 18 = 13.5 \text{ cm}^4$$

For area ④



$$I_{xy}(4) = 0 + \frac{(1)^2 \pi}{2} (1) \left( 8 + \frac{4(1)}{3\pi} \right)$$

$$= 1.571 (8.425) = 13.24 \text{ cm}^4$$

$$I_{xy_{\text{total}}} = 576 + 553.51 - 13.5 = 1102.76 \text{ cm}^4$$

$$I_{xy_{\text{total}}} = 1102.76 \text{ cm}^4$$



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11