UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

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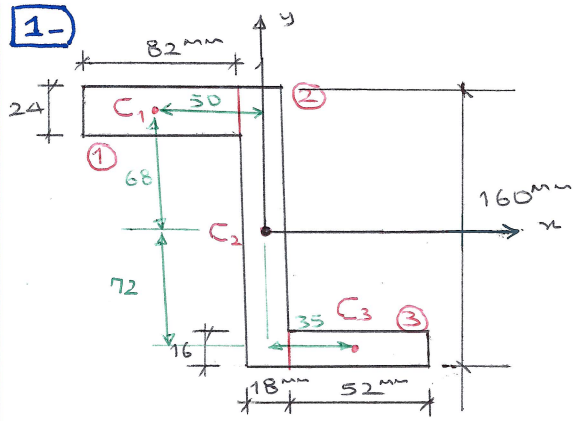
COURSE NO. CIV100F	COURSE NAME: Mechanics	Stud No. ###

Problem Set 9 (PS9)

Solution

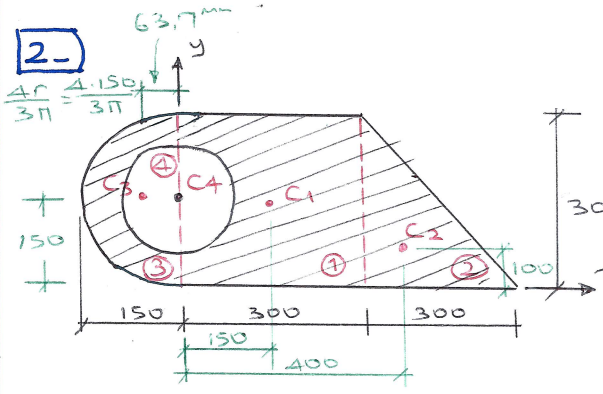
1-



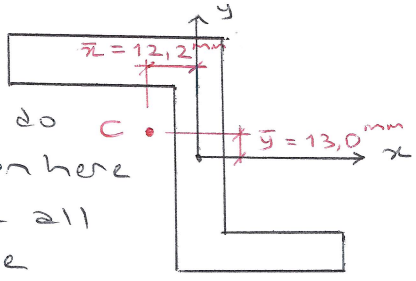
- First, divide the section into parts. Locate $\bar{x}_i$ of each part. Use a tabular solution.
- $\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A_i} = \frac{-69280}{5680} = -12,2 \text{ mm}$
- $\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = \frac{73920}{5680} = 13,0 \text{ mm}$

Part	A_i (mm²)	x_i (mm)	y_i (mm)	$A_i x_i$ (mm³)	$A_i y_i$ (mm³)
1	82·24 = 1968	-50	68	-98400	133824
2	160·18 = 2880	0	0	0	0
3	52·16 = 832	35	-72	29120	-59904
Σ =	5680			-69280	73920

2-



Answer: (1)



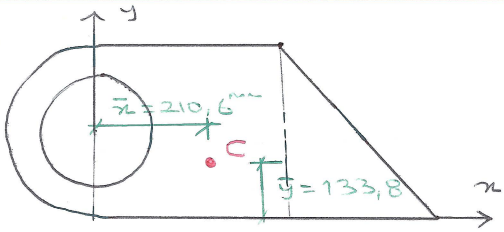
- Need to do subtraction here
- Determine all parts to be considered.
  - \+ ① : square (300×300 mm²)
  - \+ ② : triangle
  - \+ ③ : half circle (r = 150 mm)
  - − ④ : full circle (r = 100 mm)
- Locate C of all parts.
- Use a tabular solution.

Part	A_i (mm²)	x_i (mm)	y_i (mm)	$A_i x_i$ (mm²)	$A_i y_i$ (mm²)
1	300·300 = 90000	150	150	$13,5 \cdot 10^6$	$13,5 \cdot 10^6$
2	300·300/2 = 45000	400	100	$18,0 \cdot 10^6$	$4,50 \cdot 10^6$
3	π·150²/2 = 35343	-63,7	150	$-2,25 \cdot 10^6$	$5,30 \cdot 10^6$
-4	-π·100² = 31416	0	150	-0	$-4,71 \cdot 10^6$
Σ =	$138,9 \cdot 10^3$			$29,25 \cdot 10^6$	$18,59 \cdot 10^6$

- $\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A_i} = \frac{29,25 \cdot 10^6}{138,9 \cdot 10^3} = 210,6 \text{ mm}$
- $\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = \frac{18,59 \cdot 10^6}{138,9 \cdot 10^3} = 133,8 \text{ mm}$

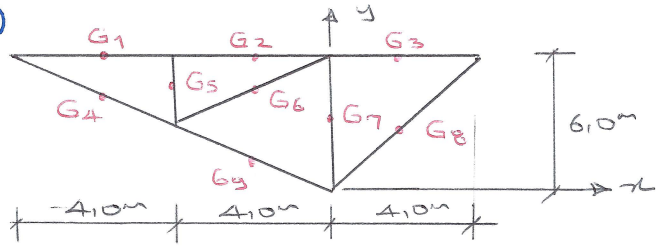
3-

Answer: Q2



- $W = 8.9 = 20\ \frac{kg}{m} \cdot 10\ \frac{m}{s^2} = 200\ \frac{N}{m}$

i-)

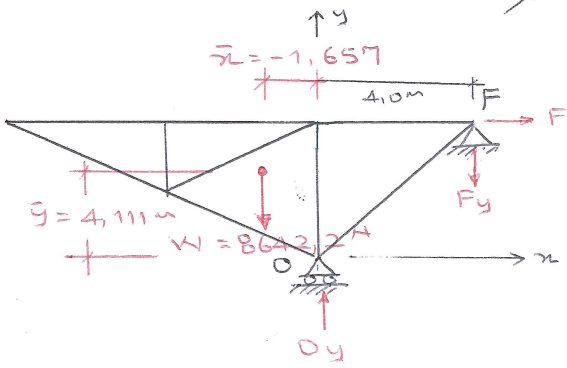


Part	Wi (N)	xi (m)	yi (m)	Wi xi (N·m)	Wi yi (N·m)
1	4,0m · 200 N/m = 800 N	-6,0	6,0	-4800	4800
2	800	-2,0	6,0	-1600	4800
3	800	2,0	6,0	1600	4800
4	5,0m · 200 N/m = 1000	-6,0	4,5	-6000	4500
5	3,0 · 200 = 600	-4,0	4,5	-2400	2700
6	1000	-2,0	4,5	-2000	4500
7	6,0 · 200 = 1200	0	3,0	0	3600
8	7,21 · 200 = 1442,2	2,0	3,0	2884,4	4326,6
9	1000	-2,0	1,5	-2000	1500
Σ =	8642,2			-14315,6	35526,6

- $\bar{x} = \frac{\Sigma W_i x_i}{\Sigma W_i} = \frac{-14315,6}{8642,2} = -1,657\ m$

- $\bar{y} = \frac{\Sigma W_i y_i}{\Sigma W_i} = \frac{35526,6}{8642,2} = 4,111\ m$

ii-)



- $\Sigma M_F = 0$

$O_y \cdot 4,0^m = 8642,2^N \cdot (4,0 + 1,657)$

$\Rightarrow O_y = 12222,2\ N\ (\uparrow)$

- $\Sigma F_y = 0$

$\Rightarrow F_y = 12222,2 - 8642,2 = 3580,0^N\ (\downarrow)$

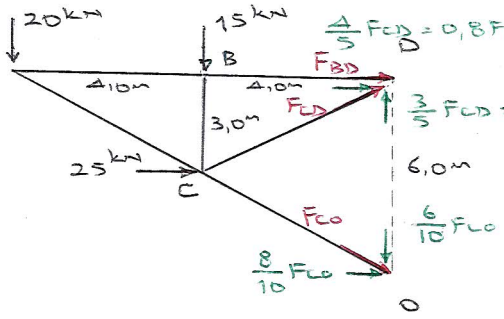
- $\Sigma F_y = 0$

$\Rightarrow F_x = 0$

- Check: $\Sigma M_O = 8642,2 \cdot 1,657 - 3580,0^N \cdot 4,0 \cong 0$ OK

(iii)

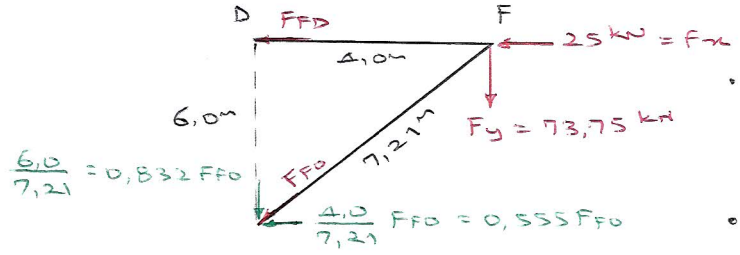
First, look at members BD, CD, and CO. Try avoiding finding support rxns. Get a section cut just at the left of member DO.



- $\Sigma M_D = 0 \Rightarrow 15 \cdot 4,0 + 20 \cdot 8,0 + 25 \cdot 3,0 + 0,8 F_{CO} \cdot 6,0 = 0$
  $\Rightarrow F_{CO} = -61,5 \text{ kN (C)}$
- $\Sigma F_y = 0 \Rightarrow 0,6 F_{CD} - 20 - 15 - 0,6 F_{CO} = 0$
  $\Rightarrow F_{CD} = -3,1 \text{ kN (C)}$
- $\Sigma F_x = 0 \Rightarrow 0,8 F_{CD} + 0,8 F_{CO} + 25 + F_{BD} = 0$
  $\Rightarrow F_{BD} = 26,7 \text{ kN (T)}$

Then look at members DF and OF. Need to find the support rxn at F.

$\Sigma M_O = 0 \Rightarrow 20 \cdot 8^m + 15 \cdot 4^m = 25 \cdot 3^m + F_y \cdot 4,0 - 25 \cdot 6 \Rightarrow F_y = 73,75^{kN}$ (F_x) ($\downarrow$)



- $\Sigma F_y = 0 \Rightarrow 0,832 F_{FO} + 73,75 = 0$
  $\Rightarrow F_{FO} = -88,6 \text{ kN (C)}$
- $\Sigma F_x = 0 \Rightarrow 25 + 0,555 \cdot F_{FO} + F_{FD} = 0$
  $\Rightarrow F_{FD} = 24,2 \text{ kN (T)}$

Check results at point O.

$\Sigma F_x \overset{?}{=} 0 \Rightarrow 0,8 F_{CO} - 0,555 F_{FO} = 0,027 \text{ kN} \cong 0$ ok ✓