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Name: Ayush Jain

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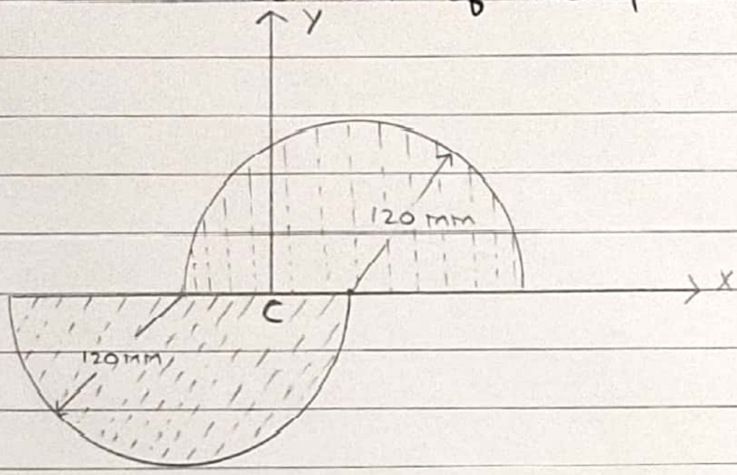
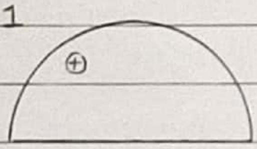
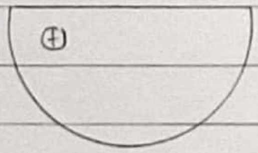
Mechanics

Assignment no. 1.1 (centroid)

1.2.4) Locate the centroid of the plane area shown.



→

Component	Area (mm^2)	x (mm)	y (mm)	Ax	Ay
1  r = 120 mm	$\pi r^2/2$ $= \frac{3.14 \times (120)^2}{2}$ $= 22608$	60	$4R/3\pi$ $= \frac{4 \times 120}{3\pi}$ $= 50.96$	1356480	1152103.68
2  r = 120 mm	22608	-60	-50.96	-1356480	-1152103.68
	$\Sigma A = 45,216$			$\Sigma Ax = 0$	$\Sigma Ay = 0$

$\therefore \quad \bar{x} = \frac{\Sigma Ax}{\Sigma A} = 0 \quad , \quad \bar{y} = \frac{\Sigma Ay}{\Sigma A} = 0$

$\therefore$ Centroid C is at (0,0) mm

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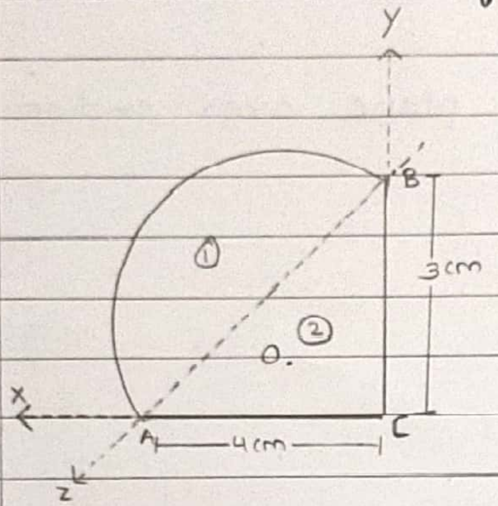
1.2.5) Find the centroid of area



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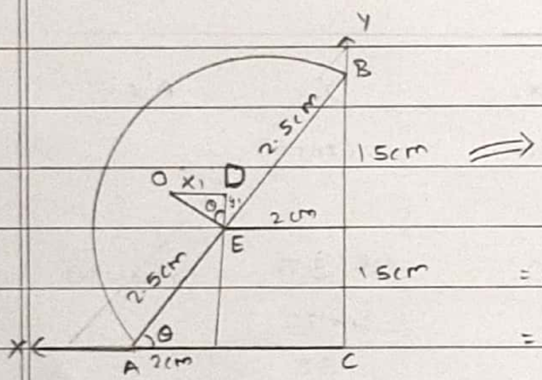
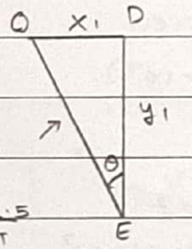


$$\frac{4R}{3\pi} = \frac{4 \times 2.5}{3\pi} = 1.06\,cm$$



$$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.87^\circ$$

$$\sin\theta = \frac{x_1}{1.06}, \qquad \cos\theta = \frac{y_1}{1.06}$$

$$\therefore \sin 36.87 = \frac{x_1}{1.06} \qquad \cos 36.87 = \frac{y_1}{1.06}$$

$$\therefore x_1 = 0.64\,cm \qquad \therefore y_1 = 0.85\,cm$$

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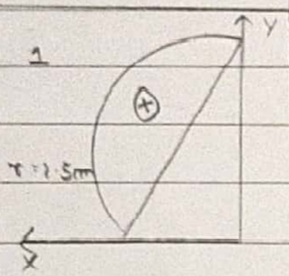
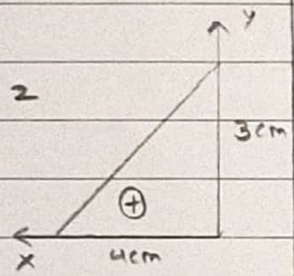
Component	Area (cm^2)	x (cm)	y (cm)	Ax	Ay
1 	$\pi R^2/2$ $= \frac{\pi \times 2.5^2}{2}$ $= 9.82$	$2 + x_1$ $= 2+0.64$ $= 2.64$	$1.5 + y_1$ $= 1.5+0.85$ $= 2.35$	25.92	23.08
2 	$\frac{1}{2} \times 3 \times 4$ $= 6$	1.333	1	8	6
	$\Sigma A = 15.82$			$\Sigma Ax = 33.92$	$\Sigma Ay = 29.08$

$$\therefore \bar{x} = \frac{\Sigma Ax}{\Sigma A}$$

$$\bar{x} = \frac{33.92}{15.82}$$

$$\bar{x} = 2.14 \text{ cm}$$

$$\therefore \bar{y} = \frac{\Sigma Ay}{\Sigma A}$$

$$= \frac{29.08}{15.82}$$

$$\bar{y} = 1.84 \text{ cm}$$

Centroid O is at (2.14, 1.84) cm

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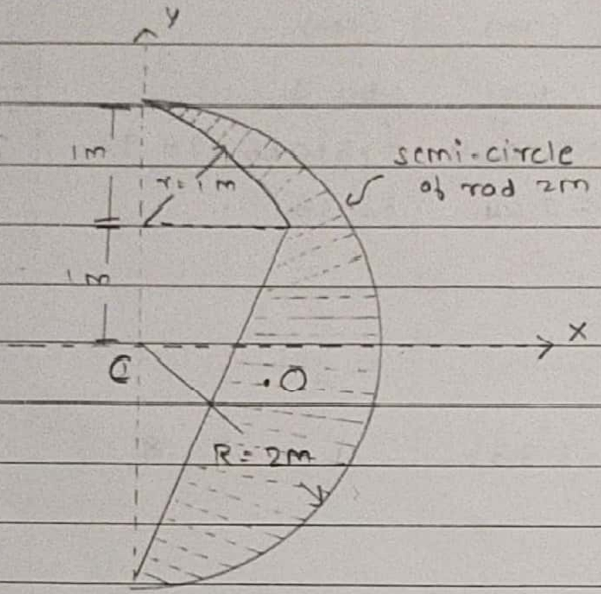
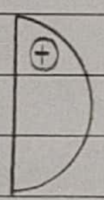
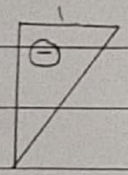
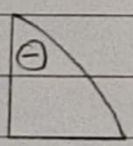
1.2.12) Find centroid.



Component	Area (m^2)	x (m)	y (m)	AX	Ay
1)  $r = 2m$	$\frac{\pi R^2}{2} = \frac{\pi \times 2 \times 2}{2} = 6.28$	$4R/3\pi = \frac{4 \times 2}{3\pi} = 0.849$	0	5.33172	0
2)  1, 3	$-\frac{1}{2} \times 1 \times 3 = -1.5$	0.333	0	-0.4995	0
3)  $r = 1m$	$-\frac{\pi R^2}{4} = -\frac{\pi \times 1^2}{4} = -0.785$	0.424	1.424	-0.33284	-1.11784
	$\Sigma A = 3.995$			$\Sigma AX = 4.49938$	$\Sigma Ay = -1.11784$

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$$\therefore \quad \bar{x} = \frac{\Sigma A x}{\Sigma A}$$

$$= \frac{4.49938}{3.995}$$

$$= 1.126\,m$$

$$\therefore \quad \bar{y} = \frac{\Sigma A y}{\Sigma A}$$

$$= \frac{-1.11784}{3.995}$$

$$= -0.28\,m$$

$\therefore$ Centroid O is at $(1.126, -0.28)\,m$

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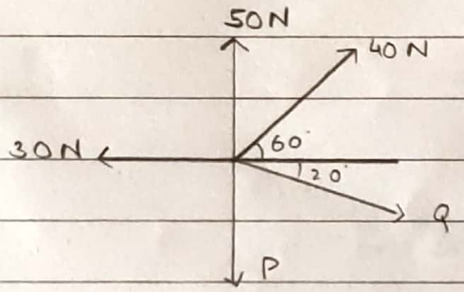
System of Coplanar forces

1.1.5) Five concurrent coplanar forces act on a body. Find the force P and Q such that the resultant of the five forces is zero.



→ According to given condition,

For Resultant (R) = 0

$\therefore \Sigma F_x = 0 \ , \Sigma F_y = 0$

$\therefore \Sigma F_x = 40\cos 60 + Q\cos 20 - 30 = 0$

$\therefore Q\cos 20 = 30 - 40\cos 60$

$\therefore Q = 10.6417\ N$

$\Sigma F_y = 0$

$\therefore 40\sin 60 - Q\sin 20 + 50 - P = 0$

$\therefore P = 40\sin 60 - Q\sin 20 + 50$

$\therefore P = 81.0013\ N$

$\therefore$ Force P is 81.0013 N and Force Q is 10.6417 N.

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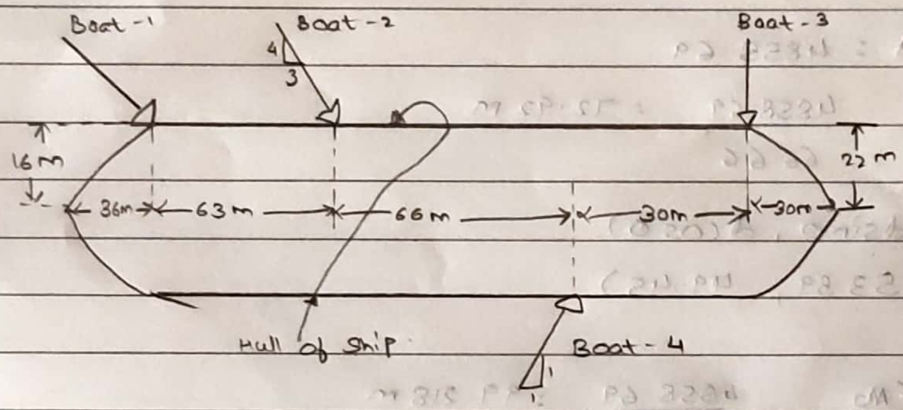
1.1.13) Four tugboats exert 25 KN to bring an ocean linear to pier. Determine the point on the hull where a single, more powerful tugboat should push to produce the same effect as the original four boats.



→ $\tan \alpha = \frac{4}{3}$

$\alpha = 53.13^\circ$

$\tan \delta = 1$

$\therefore \delta = 45^\circ$

$\Sigma F_x = 25\cos 60^\circ + 25\cos 53.13 + 25\cos 45$

$= 45.17\ KN\ (\rightarrow)$

$\Sigma F_y = (-25\sin 60 - 25\sin 53.13 - 25 + 25\sin 45)$

$= -48.97\ KN$

$= 48.97\ KN\ (\downarrow)$

$R = \sqrt{F_x^2 + F_y^2} = \sqrt{(45.17)^2 + (48.97)^2} = 66.66\ KN$

$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = \tan^{-1}\left(\frac{48.97}{45.17}\right)$

$\therefore \theta = 47.3^\circ$

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$\Sigma M_O = R \times d$

$\Sigma M_O = 25\cos60 \times 16 + 25\sin60 \times 36 + 25\cos53.13 \times 22 + 25\sin53.13 \times 99$
$- 25\cos45 \times 22 + 25\sin45 \times 16.5 + 25 \times 19.5$

$\Sigma M_O = 4858.69 \text{ kNm}$

$\therefore R \times d = 4858.69$

$d = \frac{4858.69}{66.66} = 72.92 \text{ m}$

$\therefore P = (d\sin\theta, d\cos\theta)$
$= (53.59, 49.45)$

$OB = \frac{\Sigma M_O}{\Sigma F_y} = \frac{4858.69}{48.97} = 99.218 \text{ m}$

$AC = 22\text{m}$

$BC = \frac{AC}{\tan\theta} = \frac{22}{\tan\theta} = 20.295$

Point on hull where a single resultant force can be applied is Poin A

$A = (OC, AC)$
$= (OB - BC, AC)$
$= (99.218 - 20.295, 22)$
$= [78.917, 22]$

$\therefore$ [78.917, 22] is the point on hull where single more powerful tugboat [$R = 66.66$ kN, $\theta = 47.3$] should push to produce same efforts as original 4 boats.

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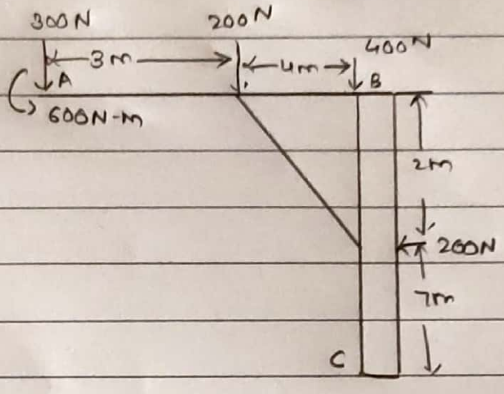
1.1.29) Replace the loading on the frame by a force and moment at point A.



$\Sigma F_x = -200\ N = 200N\ (\leftarrow)$

$\Sigma F_y = -300 - 200 - 400 = -900N = 900N\ (\downarrow)$

$R = \sqrt{F_x^2 + F_y^2} = 921.95N$

$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = 77.47°$

M_o = Moment about A (clockwise)

$\therefore M_o = 200 \times 3 + 400 \times 7 + 200 \times 2 - 600$

$= 3200 Nm\ (\circlearrowright)$

$\therefore$ The loading frame can be replaced by a force of 921.97N and an angle of 77.47° and moment of 3200 N-m clockwise.