



ENGINEERING MECHANICS - STATICS

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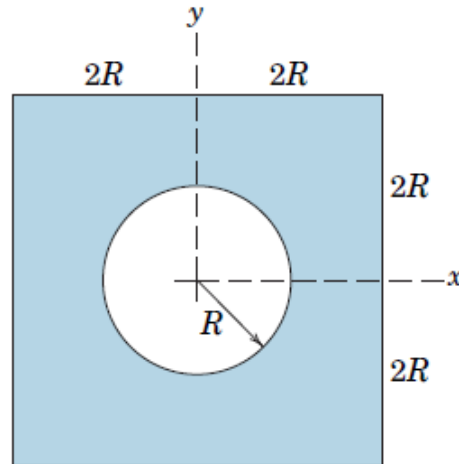
DISTRIBUTED FORCES

Session- 9

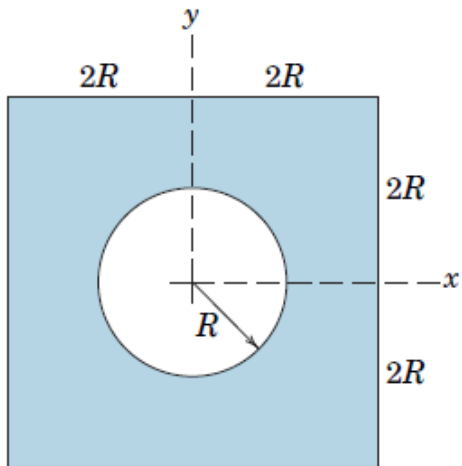
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Problem A/35. Determine the moment of inertia about the x-axis of the square area without and with the central circular hole.



SOLUTION:



Moment of inertia about the x-axis of the square area without central circular hole:

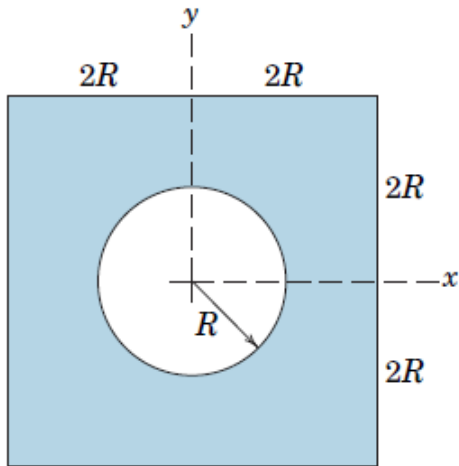
$$I_x = \frac{bh^3}{12}$$

Here,

$$b = 4R, h = 4R$$

$$I_x = \frac{(4R)(4R)^3}{12} = 21.33R^3$$

$$I_x = 21.33R^3$$



Moment of inertia about the x-axis of the square area with central circular hole:

$$I_x = \left(\begin{array}{c} \text{MI of a square lamina} \\ \text{about } x - \text{Axis} \end{array} \right) - \left(\begin{array}{c} \text{MI of a circle about} \\ x - \text{Axis} \end{array} \right)$$

$$I_x = \left(\frac{bh^3}{12} \right) - \left(\frac{\pi r^4}{4} \right)$$

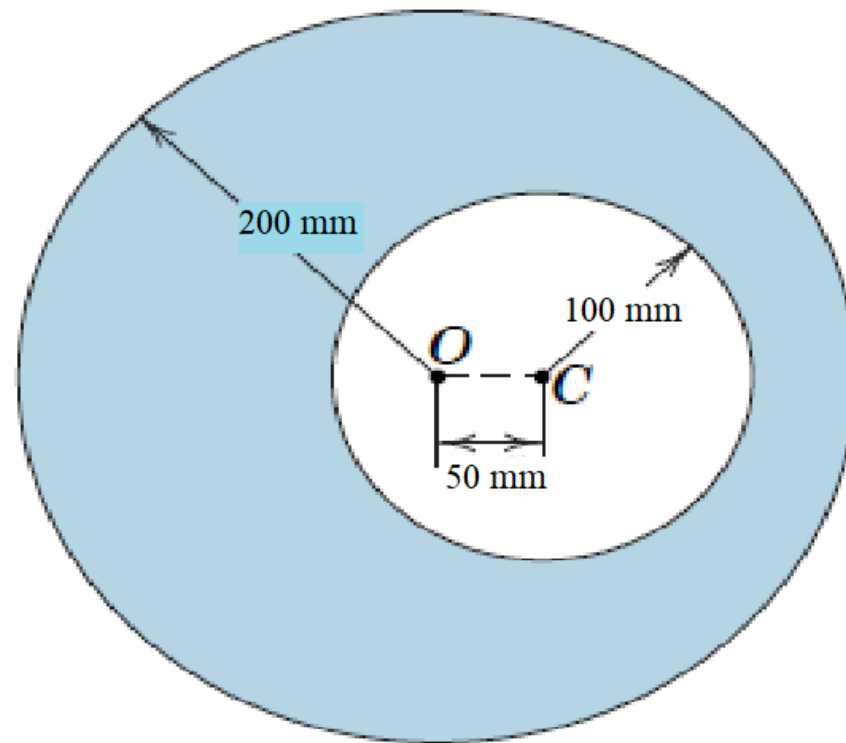
Here,

$$b = 4R, h = 4R \text{ \& } r = R$$

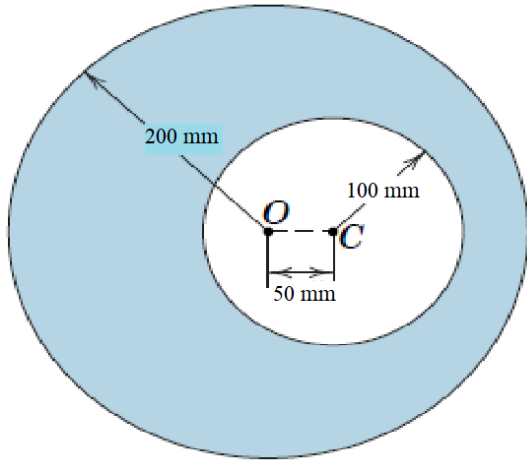
$$I_x = \left(\frac{(4R)(4R)^3}{12} \right) - \left(\frac{\pi R^4}{4} \right) = 20.55 R^4$$

$$I_x = 20.55 R^4$$

Problem A/39. Calculate the polar radius of gyration of the shaded area about the center O of the larger circle.



SOLUTION:



Polar Radius of Gyration of the shaded area about the Center "O": K_z

$$K_o = \sqrt{\frac{I_z}{A}} \quad \text{Here, } I_z \text{ is PMI of the shaded area about point "O" \& A is shaded area.}$$

$$I_z = I_x + I_y \quad \text{Here } I_x, I_y \text{ are the MI of the shaded area about x and y - axis}$$

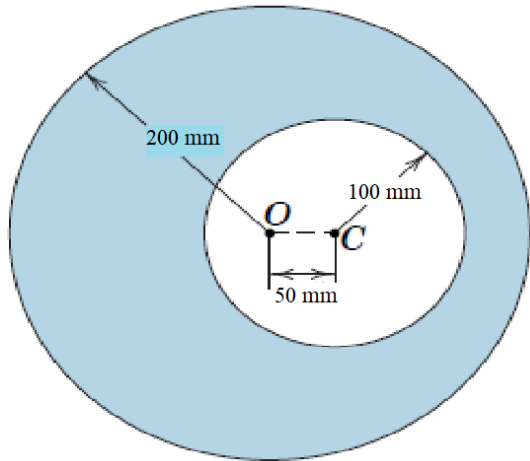
$$I_x = \left(\begin{array}{c} \text{MI of a larger circle} \\ \text{about x - Axis} \end{array} \right) - \left(\begin{array}{c} \text{MI of a smaller circle about} \\ \text{x - Axis} \end{array} \right) \text{-----(1)}$$

$$\text{MI of a larger circle about x - axis} = \frac{\pi R^4}{4} \quad \text{here } R = 200\text{mm}$$

$$\text{MI of a smaller circle about x - axis} = \frac{\pi R^4}{4} \quad \text{here } R = 100\text{mm}$$

Substituting in equation (1)

$$I_x = \left(\frac{\pi 200^4}{4} \right) - \left(\frac{\pi 100^4}{4} \right) = (12.566 \times 10^8) - (0.7854 \times 10^8) = 11.78 \times 10^8 \text{mm}^4$$



$$I_y = \left(\begin{array}{c} \text{MI of a larger circle} \\ \text{about } y - \text{Axis} \end{array} \right) - \left(\begin{array}{c} \text{MI of a smaller circle about} \\ y - \text{Axis} \end{array} \right) \text{-----(2)}$$

$$\text{MI of a larger circle about } y - \text{axis} = \frac{\pi R^4}{4} \text{ here } R = 200\text{mm}$$

$$\begin{aligned} \text{MI of a smaller circle about } y - \text{axis} &= \bar{I}_y + Ad^2 \\ &= \frac{\pi R^4}{4} + \frac{\pi R^2}{2} d^2 \text{ here } R = 100\text{mm}, d = 50\text{mm} \end{aligned}$$

Substituting in equation (2)

$$I_y = \left(\frac{\pi 200^4}{4} \right) - \left(\left(\frac{\pi 100^4}{4} \right) + (\pi 100^2)(50)^2 \right) = (12.566 \times 10^8) - (1.57 \times 10^8) = \mathbf{10.99 \times 10^8 \text{mm}^4}$$

$$I_z = I_x + I_y = 11.78 \times 10^8 + 10.99 \times 10^8 = \mathbf{22.775 \times 10^8 \text{mm}^4}$$

$$A = (\pi 200^2) - (\pi 100^2) = \mathbf{\pi 30000 \text{mm}^2}$$

$$K_z = \sqrt{\frac{I_z}{A}} = \sqrt{\frac{22.775 \times 10^8}{\pi 30000}} = 155.45\text{mm}$$

$K_z = 155.45 \text{ mm}$



THANK YOU

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