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MECHANICS
SUB. CODE-BSPH1102
For B.Sc.(Physics & Chemistry)
(Rotational Dynamics)

Calculation of moment of inertia for rectangular, cylindrical bodies

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MI of a circular ring about a perpendicular line passing through the center

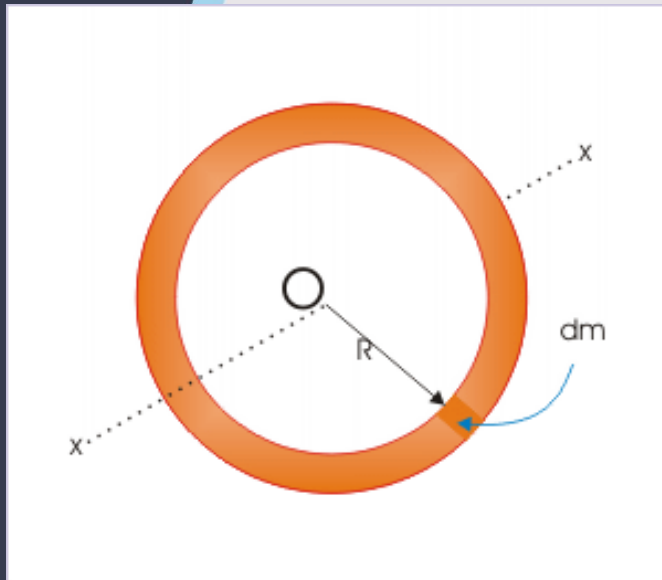
Let us consider a circular ring of mass M and radius R .

Let us consider a small element of Mass ' dm '.

MI of the element about the axis through the centre = $R^2 dm$

Hence MI of the ring

$$I = \sum R^2 dm = \int R^2 dm$$
$$= R^2 \int dm = MR^2$$





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MI of a thin circular disc about a perpendicular axis passing through the center

Let M = Mass of the disc

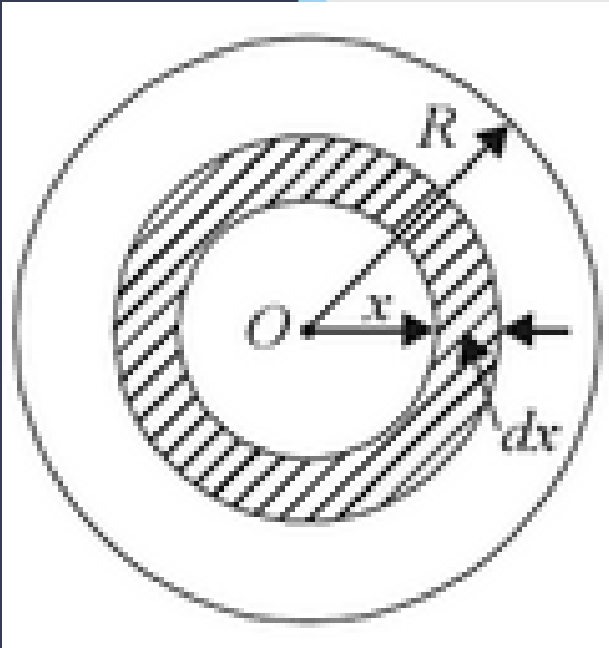
R = radius of the disc

$$\text{Areal density, } \sigma = \frac{M}{A} = \frac{M}{\pi R^2}$$

Let us consider an small circular ring element of width " dx ", which is situated at a linear distance " x " from the axis.

$$\begin{aligned} \text{Area of the element} &= \text{circumference} \times \text{width} \\ &= 2\pi x dx \end{aligned}$$

$$\begin{aligned} \text{Mass of the element} &= \frac{M}{\pi R^2} \times 2\pi x dx \\ &= \frac{2M}{R^2} x dx \end{aligned}$$





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MI of the ring about the axis = mass \times distance²

$$dI = \frac{2M}{R^2} x dx \cdot x^2 = \frac{2M}{R^2} x^3 dx$$

Hence MI of whole disc about the axis,

$$\begin{aligned} I &= \int_0^R \frac{2M}{R^2} x^3 dx \\ &= \frac{2M}{R^2} \int_0^R x^3 dx = \frac{2M}{R^2} \left[\frac{x^4}{4} \right]_0^R = \frac{2M}{R^2} \times \frac{R^4}{4} = \frac{1}{2} MR^2 \end{aligned}$$



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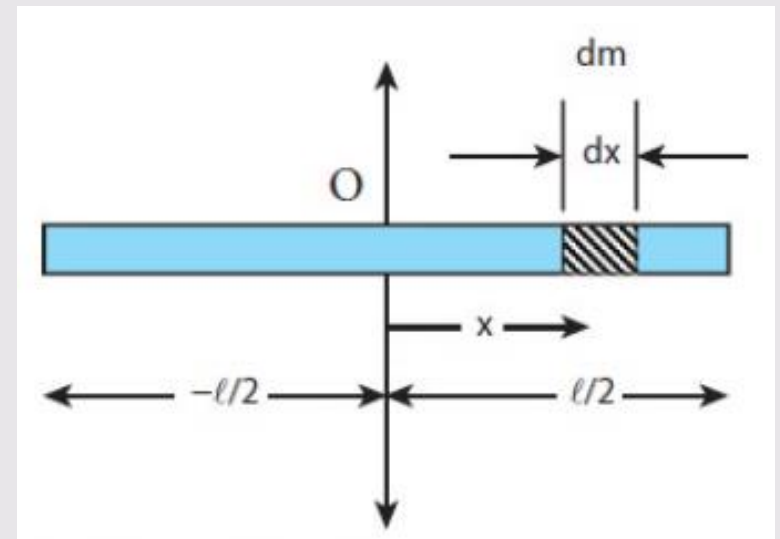
MI of a thin rod

a) About an axis passing through the centre and perpendicular to its length'

Let the length= l

Mass= M , Mass/length= M/l , Let dx be small length of the rod at a distance x from 'O'

$$dI = \frac{M}{l} x^2 dx$$
$$I = \int_0^l dI = \frac{M}{l} \int_{-l/2}^{l/2} x^2 dx$$
$$I = \frac{Ml^2}{12}$$





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MI of a solid cylinder

About its own axis

R =Radius, l =length

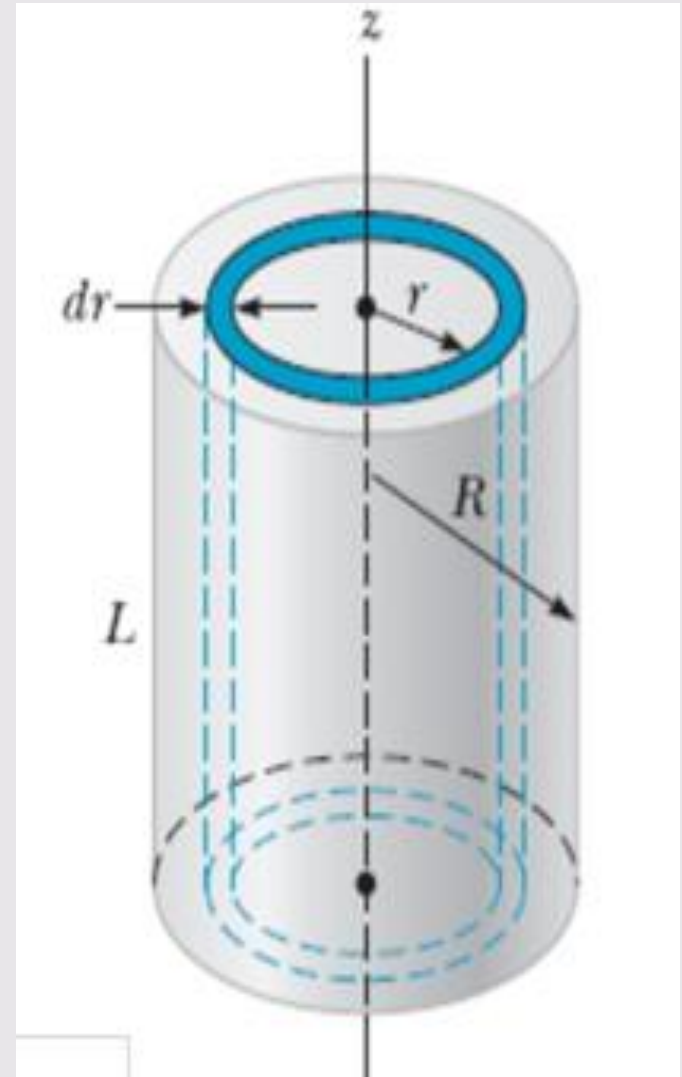
M =Mass, Volume= $\pi R^2 l$

Mass/Volume= $M / \pi R^2 l$

Mass of elementary cylindrical
shell= $(M / \pi R^2 l) \times 2\pi x l dx =$
 $\frac{2M}{R^2} x dx$

$$dI = \frac{2M}{R^2} x^3 dx$$

$$I = \frac{1}{2} MR^2$$





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Reference

Mechanics by *D. S. Mathur*, S. Chand, chp-11.8 to
11.9

