Q-1 (Sub)

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Torsion and rigidity modulus.

[Continued ....]

$\therefore F = \frac{n x \theta}{l}$

Now this force area of this hollow cylinder
$= 2\pi x dx$

$\therefore$ Total shearing force on this area
$= 2\pi x dx \times \frac{n x \theta}{l}$

$= 2\pi n \cdot \frac{\theta}{l} x^2 dx$

Therefore, moment of this force about the axes OO' is equal to $= 2\pi n \cdot \frac{\theta}{l} x^2 dx \times x$

$= \frac{2\pi n \theta x^3 dx}{l}$

Integrating this expression between the limits $x = 0$ to $x = r$, we have

Total twisting couple on the cylinder

$= \int_0^r \frac{2\pi n \theta x^3 dx}{l}$

$= \frac{2\pi n \theta}{l} \int_0^r x^3 dx$

$= \frac{2\pi n \theta}{l} \left[\frac{x^4}{4}\right]_0^r$

$= \frac{2\pi n \theta \cdot r^4}{4l}$

$= \frac{\pi n \theta r^4}{2l}$

If $\theta = 1$ radian, we have twisting couple per unit twist of the cylinder a wire

$C = \frac{\pi n r^4}{2l}$

This twisting couple, per unit twist of the wire is also called the torsional Rigidity.