TORSIONAL PENDULUM:

When the Specimen; whose rigidity modulus is to be found is given in the form of a wire torsional pendulum i.e the dynamical method. is applied

One end of the experimental wire is clamped on a fixed support and at its free end; a heavy bole of regular geometrical shape such as a solid sphere or a hollow shell or a circular disc or a cylinder, such that the formula for its M.I is known, is suspended.

The bole is given a very small angular twist about the suspension wire as axis. The wire is also twisted along with the bole and due to the torsional rigidity a restoring couple, equal and opposite to the torsional couple sets in. When the bob is let free i.e released, due to restoring couple, the bob comes back to its original position. Since it gains some velocity, it does not stop and overshoots its original position and wire is twisted and again a restoring couple in the reverse direction sets in; which will bring the bob back to its original position again. In this way the bob executes torsional oscillation.

Let ϕ be the angle of twist at the free end

$$\therefore \text{ Torsional couple } \Gamma = C\phi \quad \text{where } C = \frac{\pi n r^4}{2l} \longrightarrow (1)$$

$$\text{Restoring couple} = -C\phi$$

Using Newtons 2nd law:-

$$I \times \text{ang. accelaration} = \text{Restoring couple} = -C\phi$$
$$= -C \times \text{angular displacement}$$

$$\text{or ang. accl}^n = -\frac{C}{I} \cdot \text{ang. displacement} \longrightarrow (2)$$

Since for a given wire C is a const. and for a given bob I is constant hence from equation (2):-

$$\text{ang. accelaration} \propto - \text{ang. displacement}$$

Hence the torsional oscillation is simple harmonic

Let T = Time period of torsional oscillation

Using the expression for time period of a S.H.M

$$T = 2\pi\sqrt{\frac{\text{ang. displacement}}{\text{ang. accelaration}}} \longrightarrow (3)$$

Putting (3) in (2) :-

$$T = 2\pi\sqrt{\frac{I}{C}} \longrightarrow (4)$$

Equation (4) gives the time period of a torsional pendulum.

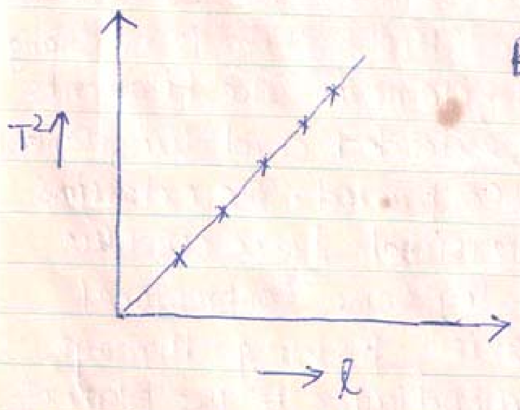
Squaring equation (4) putting equation (1) :-

$$T^2 = 4\pi^2 \cdot \frac{I}{C} = \frac{4\pi^2 I}{\frac{\pi n r^4}{2l}} = \frac{8\pi I l}{n r^4}$$

$$\therefore n = \frac{8\pi I l}{T^2 r^4} \longrightarrow (5)$$

$I = \frac{2}{5} MR^2$, for a solid sphere. Using Equation (5) n can be calculated.

The experiment is repeated for different values of l and for each value corresponding T is measured. A graph between l and T^2 is plotted. The graph is found to be a straight line as shown.



Remark: Radius of the wire is very small and since it occurs in the power four hence it should be measured very very accurately, a small error e becomes $4e$ in actual calculation.

$[r^4 = (r \pm e)^4 = r^4 + 4e \cdot r]$