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Determination of Modulus of Rigidity (*n*) of the Material of a Wire by Dynamical Method

- **Theory:**

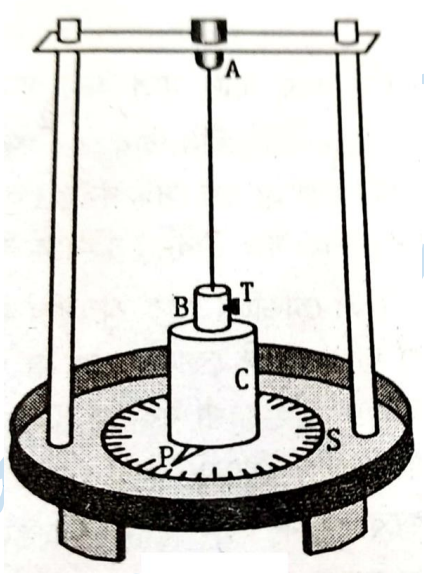

Figure: Instrument for determining rigidity modulus

The time-period T with which the bob of a torsion pendulum oscillates, with its suspension wire as axis, is given by,

$$T = 2\pi \sqrt{I/c}$$

$$\text{Or,} \quad c = \frac{4\pi^2 I}{T^2} \quad \ldots (1)$$

where, I is the moment of inertia of the suspended cylinder about its own axis and is given by,

$$I = \frac{1}{2} \times M \times R^2 \quad \ldots (2)$$

where, M = mass of the bob

R = radius of the bob

and *c* represents the couple exerted by the suspension wire of length *l* and radius *r* for one radian twist at its free end and is given by,

$$c = \frac{\eta \pi r^4}{2l} \qquad \ldots (3)$$

where, n = rigidity modulus of the material of the wire.

From equations (1) and (3), we can write,

$$\frac{4\pi^2 I}{T^2} = \frac{\eta \pi r^4}{2l}$$

$$\text{Or,} \qquad \eta = \frac{8\pi l}{T^2 r^4} \times I \qquad \ldots (4)$$

At first calculate *I* from equation *(2)*. Then by measuring *r*, *l* and *T* calculate η from equation (4). SI unit of rigidity modulus will be in $^{N}/_{m^2}$.

(next page)

- **Experimental Data:**

(A) *Determination of the moment of inertia (I) of the suspended cylinder*:

(i) Mass of the cylinder = M = ... *kg* (given)

(ii) Determination of Vernier constant:

1 small division of main scale = *0.1 cm*

Now, 10 vernier divisions = 9 small main scale divisions
or, 1 v.d. = $\frac{9}{10}$ *s.m.d*

So, Vernier constant = 1 small main scale division – 1 vernier division
= $(1 - \frac{9}{10})$ *x 0.1 = 0.01 cm*

(iii) Determination of mechanical error (e) of Slide Callipers:

$e = \pm y \times v$ *cm* [where y is the initial reading of erroneous slide calipers]

Table – I: Calculation of Radius (R) of the Cylinder

No. of Observations	Measuring Quantity (Diameter)	Main Scale Reading (In *cm*)	Vernier Reading	Total Reading $= S + N \times v$	Mean D´ (In *cm*)	Corrected Diameter D = D´ - e (In *cm*)	Radius (R) (In *m*)
1	Diameter at one point						
	Diameter at another point perpendicular to previous						
2							
3							
4							
5							

So from equation (2), $I = \frac{1}{2} \times M \times R^2 =$ ..... *kg-m*^{2}

(B) *Measurement of the Length (l) of the suspension wire:*

$l = \frac{\ldots + \ldots + \ldots}{3}$ *m* = ... *m*

(C) *Measurement of the radius (r) of the suspension wire:*

Measuring Least Count of Screw Gauge:

Smallest division of least count = S = ... *mm*

Pitch of the screw = p = ... *mm*

Number of divisions on the circular scale = N =.....

Least count of instrument = L.C. = $\frac{P}{N}$ = ... *mm*

mechanical error (e) of Screw Gauge:

$e = \pm y \times v$ *mm* [where y is the initial reading of erroneous screw gauge]

Table – II: Calculation of Radius (r) of the Suspension Wire

Serial No.	Measuring Quantity (Diameter)	Linear Scale Reading (LSR) (In *mm*)	Circular Scale Reading (CSR)	Diameter (in *mm*) Total = LSR+ (C.S.R X L.C.)	Mean D´ (In *mm*)	Corrected Diameter D = D´- e (In *mm*)	Radius (r) (In *m*)
1	Diameter at one point						
	Diameter at another point perpendicular to previous						
2							
3							
4							
5							

(D) *Determination of the time-period of torsional oscillation (T) of the cylinder*:

Table – III

No. of obs.	Time for 30 oscillations (in *s*)	Mean time *t* (in *s*)	Time-period $T = \frac{t}{30}$ (in *s*)
1. 2. 3. 4. 5.	....	.....	.....

- **Calculations:**

From experiment, we have,

I = ... $kg\text{-}m^2$ l = ... m

r = ... m T = ... s

Then, $\eta = \frac{8\pi l}{T^2 r^4} \times I$ = ... N/m^2