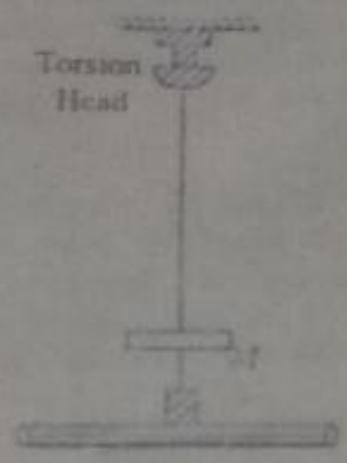
Expt. No. 4. To determine the modulus of rigidity of a wire by solid cylinderical rod (oscillating rod).

Apparatus : *Solid cylinderical rod, copper wire of suitable length and radius, support with torsion head, stop watch, vernier callipers, screw gauge, spring balance, metre rod and telescope.*



Observations and Calculations

Length of suspension wire	$= l$ = ... cm.
Length of oscillating rod	$= L$ = ... cm.
Mass of the solid cylinderical rod	= (1) . . . . . (2) . . . . .
Average mass	$= m = \frac{(1) + (2)}{2}$ = ... gm.
Value of the smallest scale division	$= S$ = 1 mm = 0.1 cm.
No. of divisions on the vernier scale	$= N$ = 10
Vernier constant (*V.C.*)	$= \frac{\text{Vlue of the smallest scale division}}{\text{No.of divisions on the vernier scale}}$ $= \frac{S}{N} = \frac{1}{10}$ mm = 0.1 mm = 0.01 cm.
Diameter of the solid cylinderical rod	= (1) . . . . . (2) . . . . . (3) . . . . .
Mean diameter	$= D$ = ... cm.
Radius of the solid rod	$= R = \frac{D}{2}$ = ... cm.
Pitch of the screw	$= h$ = ... mm.
No. of circular scale divisions	$= n$ = ... divisions.
Least count (*L.C.*)	$= \frac{\text{Pitch of the screw}}{\text{No. of circular scale divisions}}$ $= \frac{h}{n}$ = ... mm = ... cm.
Diameter of the suspension wire	= (1) . . . . . (2) . . . . . (3) . . . . .
Mean diameter of the wire	$= d$ = ... cm.
Radius of the suspension wire	$= r = \frac{d}{2}$ = ... cm

Time period of oscillating rod:

Time for 20 vibrations				Time period $T = \frac{t}{20}$
t_1	t_2	t_3	Mean t	
sec.	sec.	sec.	sec.	sec.

$\eta = \frac{8\pi m l}{T^2 r^4}\left(\frac{L^2}{12} + \frac{R^2}{4}\right)$ = ... dynes/sq. cm or dynes cm^{-2}

Correct value of η = ... dynes/sq. cm or dynes cm^{-2}

Percentage error = ... %

Procedure:

1. Measure the length of the oscillating rod and that of the suspension wire. Measure the diameter of the rod and that of the suspension wire accurately with the help of vernier callipers and screw guage respectively. Determine the mass of the oscillating rod accurately.

2. Suspend the solid cylinderical rod horizontally from a rigid support by means of a long wire (1.5 metres) free from kinks. Ensure that it hangs in the plane of the wall with the mirror facing you.

3. Fix a knitting needle vertically in front of and about 5 cm from the mirror with its tip in level with the centre of the plane mirror M. Focus a telescope from a distance of at least two metres on the image of the needle tip as seen in the mirror.

4. Tie one end of the thread to the rod and its other end to a fixed point (or simply press one end of the rod slightly backward and leave it).

5. Apply a burning match stick to the thread to make the rod vibrate in a horizontal plane. Ensure that the amplitude is small and it does not oscillate up and down.

6. When the image of the needle tip crosses the cross-wire to the right, start the stop watch and count zero. Count one when the image once again crosses the vertical cross-wire to the right. Find time for 20 vibrations and repeat it thrice. Work out the time period T.

7. Make record of your observations as shown and apply the relation

$$\eta = \frac{8\pi m l}{T^2 r^4}\left(\frac{L^2}{12} + \frac{R^2}{4}\right)$$

to find out the modulus of rigidity of the wire.

Sources of error and precautions:

The experimental wire should be free from kinks.
The rod should be arranged to vibrate equally on both sides of the reference image of the needle tip.
The thickness of the experimental wire should be such that it remains taut under the load of the needle.

4. The rod should vibrate in a horizontal plane and parallel to the wall carrying the support.
5. The amplitude of torsional vibration should be small to keep the wire within elastic limit under the twisting couple.
6. The air-draughts should be avoided during actual performance of the experiment.
7. The diameter of the wire should be determined at different points extended along whole length of the wire.
8. The vibrations should be counted with reference to the movement of the image in the same direction (i.e. left or right) only.
9. The diameter of the rod should be determined with a vernier callipers.

Viva Voce :

Q.1. What do you mean by elasticity?
Ans. The inherent property of a material body to regain its original condition after the deforming forces cease to act is called elasticity.

Q.2. What is stress?
Ans. The restoring force per unit area set up in the body is called stress.

Q.3. What is strain?
Ans. The change produced per unit dimension of a body is called strain and is measured by the change per unit length (longitudinal strain), per unit volume (volume strain) or change in angle (shearing strain) according as the change in length, volume or shape of the body.

Q.4. What do you understand by modulus of rigidity?
Ans. It is defined as the ratio of tangential stress to the shearing strain.

Q.5. What is Hooke's law?
Ans. It states that the strain produced is directly proportional to stress applied i.e. stress/strain = constant.

Q#5 What is Hooke's law??

Kinks