Teacher's Signature: _____
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United International University

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Experiment No. 06

Name of the Experiment: Determination of the modulus of rigidity of a wire by the method of oscillations (Dynamic Method).

Theory:

If a heavy body is supported by a vertical wire of length l and radius r so that the axis of the wire passes through its center of gravity, and if the body is turned through an angle and released, it will execute torsional oscillations about a vertical axis. If, at any instant, the angle of twist is θ, the moment of the torsional couple exerted by the wire will be,

$$\frac{n\pi r^4}{2l}\theta = C\theta \quad \ldots\ldots\ldots (1)$$

Where, $\frac{n\pi r^4}{2l} = C$ is a constant and n is the modulus of rigidity of the material of the wire.

Therefore, the motion is simple harmonic and of fixed period.

$$T = 2\pi\sqrt{\frac{I}{C}} \quad \ldots\ldots\ldots (2)$$

Where, I is the moment of inertia of the body.

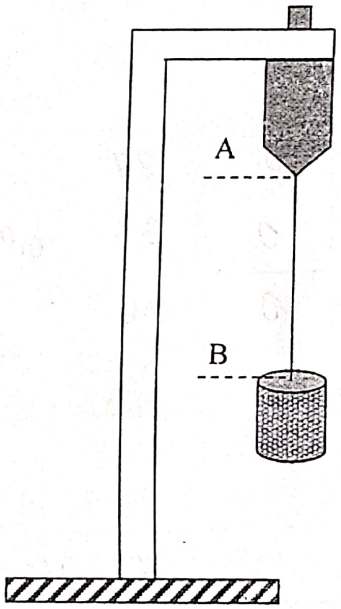


Fig. 01

From equations (1) and (2), we have,

$$T^2 = \frac{4\pi^2 I}{C} = \frac{8\pi I}{nr^4}l \qquad \text{Or, } n = \frac{8\pi I}{T^2 r^4}l \text{ dynes/cm}^2$$

Note: For a cylindrical object, having mass M and radius a, the moment of inertia is given as,

$$I = \tfrac{1}{2}Ma^2$$

Apparatus:

- A uniform wire
- A cylindrical bar
- Suitable clamp
- Stopwatch
- Screw gauge
- Vernier scale
- Meter scale etc.

Experimental Data:

(A) Mass of the cylinder, M = 1110 gm

(B) Length of the wire, l = 70 cm.

(C) Table for the radius of the cylinder, a

No. of obs.	MSR, x (cm.)	VSR	V.C (cm.)	y = VSR ×V.C (cm.)	Total reading, x+y (cm.)	Mean Diameter (cm.)	Radius, a = D/2 (cm.)
1	4.6	20	0.00852	0.04	4.64	4.64	2.32
2	4.6	17		0.034	4.634		
3	4.6	16		0.032	4.632		

(D) Moment of Inertia of the cylinder, $I = \frac{1}{2}Ma^2$ = 2987.232 gm cm

(E) Table for the radius of the wire, r

No. of obs.	LSR, x (cm.)	CSR	Least Count (cm.)	Value of CSR, y (cm.)	Total reading, x+y (cm.)	Mean Diameter (cm.)	Instrumental error	Correct diameter (cm.)	Radius, r = D/2 (cm.)
1	0	37	0.001	0.037	0.037	0.036	0	0.036	0.018
2	0	36		0.036	0.036				
3	0	36		0.036	0.036				

(F) Table for the time period, T

No. of obs.	Time for 10 oscillations	Period of oscillation, T (sec.)	Mean T (sec.)
1	71.00	7.1	7.112
2	71.05	7.105	
3	71.31	7.131	

Calculation:

The modulus of rigidity of the wire is, $n = \frac{8\pi I}{T^2 r^4} l = \frac{8 \times 3.1416 \times 2987.232}{(7.112)^2 \times (0.018)^4} \times 70$

$= 9.89 \times 10^{11}$ dyne/cm

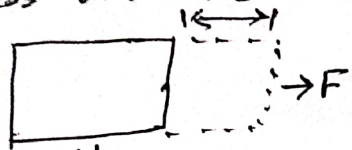
Result:

The modulus of rigidity of the wire is, n = 9.89×10^{11} dyne/cm

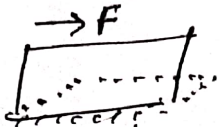
Discussions:

Q: Define Rigidity Modulus of elasticity. What is the difference between Young's Modulus and Rigidity Modulus?

For a parallel surface when force applied, shear stress is produced which is turn produces share strain. The ratio between the shear stress and shear strain is Rigidity Modulus.



$\epsilon = \frac{\Delta L}{L_0}$ (Normal strain)



$\theta = \tan\theta$ (shear strain)

The difference between in Young Modules force is applied perpendicularly but in Rigidity Modules force is applied parallelly.

Q: What type of oscillation did you observe in this experiment? Explain.

A torsion pendulum is analogous to a mass-spring oscillator. Instead of a mass at the end of a helical spring, which oscillates back and forth along a straight line, however, it has a mass at the end of a torsion wire, which rotates back and forth. To set the mass spring in motion, you displace the mass from its equilibrium position by moving it in a straight line and then release it.

Q: On what factors does the time period of oscillation depend?

There are four factors which act to lengthen the period of the pendulum. The increase in the moment of inertia due to the masses of the added weights. the change in dimensions of the suspending wire. the decreased torsion stiffness of the wire and the energy used in raising and lowering the disk.

Q: Does the rigidity change with change in temperature?

If decrease with increment of temparature.

So, it is changes.

Q: If you now replace the wire that you have used to perform the experiment with a wire of large radius but of the same length and material, how the modulus of rigidity will change? Explain.

Since Rigidity only depends on the material so the by replacing the wire with same length and material will not change the rigidity.

Q: On what factors does the degree accuracy of the result depend?

There are four factors which act to lengthen the period of the pendulum:

(1) The increase in the moment of inertia due to the masses of the adder weights.

(2) The change in dimensions of the suspending wire.

(3) The decreased torsion stiffness of the wire.

(4) The energy used in raising and lowering the d.

Q: What is the standard value of the *Rigidity Modulus* of the material used to perform the experiment?

The standard value of the Rigidity Modulus of the material used to perform the experiment is 9.89×10^{11} dynes/cm^2.