Teacher's Signature:____________
Date: ______________________

United International **University**

Name: ____ ID: ______________

Section: ______ Batch: _____________ Date: ________________________

Experiment No. 08

Name of the Experiment: Determination of the moment of inertia of the given disc using Torsion pendulum by the method of oscillations (Dynamic Method).

Theory:

A body suspended by a thread or wire which twists first in one direction and then in the reverse direction, in the horizontal plane is called a torsional pendulum. The first torsion pendulum was developed by Robert Leslie in 1793. A simple schematic representation of a torsion pendulum is given here, Fig. 01.

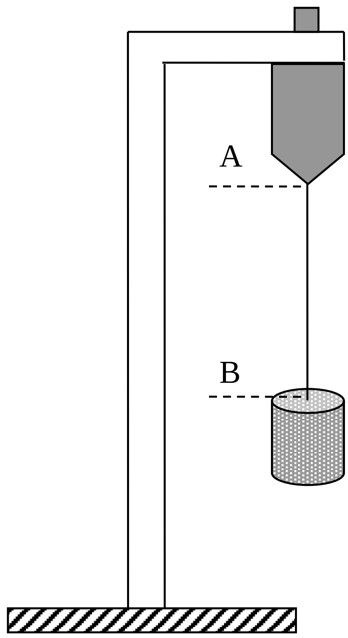

Fig. 01

C

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.

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,

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

Now, let I_0 be the moment of inertia of the disc alone and I_1 & I_2 be the moment of inertia of the disc with identical masses at distances d_1&d_2 respectively. If I_1 is the moment of inertia of each identical mass about the vertical axis passing through its centre of gravity, then

$$I_1 = I_0 + 2\ I^1 + 2md_1^2 \ldots\ldots\ldots (3)$$

$$I_2 = I_0 + 2I^1 + 2md_2^2 \ldots\ldots\ldots\ldots (4)$$

$$I_2 - I_1 = 2m(d_2^2 - d_1^2) \ldots\ldots\ldots (5)$$

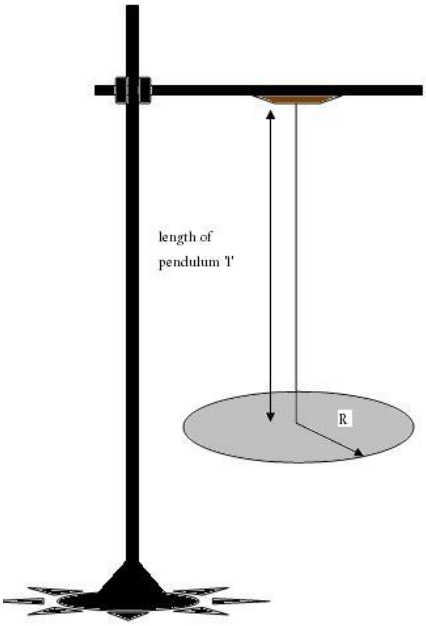

Fig.02: A torsional pendulum with disc.

But from equation (2),

$$T_0{}^2 = 4\pi^2 \frac{I_0}{C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$T_1{}^2 = 4\pi^2 \frac{I_1}{C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$T_2{}^2 = 4\pi^2 \frac{I_2}{C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$T_2{}^2 - T_1{}^2 = \frac{4\pi^2}{C}(I_2 - I_1) \ldots\ldots\ldots (9)$$

Where T_0, T_1, T_2 are the periods of torsional oscillation without identical mass, with identical pass at position d_1, d_2 respectively. Dividing equation (6) by (9) and using (5),

$$\frac{T_0{}^2}{\left(T_2{}^2 - T_1{}^2\right)} = \frac{I_0}{[I_2 - I_1]} = \frac{I_0}{2m\left(d_2{}^2 - d_1{}^2\right)} \ldots\ldots\ldots (10)$$

Therefore, the moment of inertia of the disc using identical masses,

$$I_0 = 2m\left(d_2{}^2 - d_1{}^2\right)\frac{T_0{}^2}{\left(T_2{}^2 - T_1{}^2\right)} \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Procedure for Simulation

1. The radius of the suspension wire is measured using a screw gauge.
2. The length of the suspension wire is adjusted to suitable values like 0.3m, 0.4m, 0.5m,.....0.9m, 1m etc.
3. The disc is set in oscillation. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_0 '.
4. The two identical masses are placed symmetrically on either side of the suspension wire as close as possible to the centre of the disc, and measure d_1 which is the distance between the centres of the disc and one of the identical masses.
5. Find the time for 20 oscillations twice and determine the mean period of oscillation 'T_1 '.
6. The two identical masses are placed symmetrically on either side of the suspension wire as far as possible to the centre of the disc, and measure d_2 which is the distance between the centres of the disc and one of the identical masses.

7. Find the time for 20 oscillations twice and determine the mean period of oscillation 'T_2'.
8. Find the moment of inertia of the disc using the given formulae.

Apparatus:

- A uniform wire
- Two identical cylindrical masses
- Suitable clamp
- Stopwatch
- Screw gauge
- Given torsional pendulum
- Vernier scale
- Meter scale etc.

Experimental Data:

(A) Mass of each identical masses, m =

(B) Length of the suspension wire, *l* =

(C) Radius of the suspension wire, r =

(D) d_1= and d_2=

(E) Radius of the disc, a =

(F) Mass of the disc or cylinder, M=

(G) Moment of Inertia of the cylinder (using simulator), I = ½Ma^2 =

(H) Table for the time period, T

No. of obs.	Length of the suspension wire, *l* (cm)	Time for 20 oscillations (s)									Period of oscillation (s)			$T_o^2/(T_2^2 - T_1^2)$	Mean $T_o^2/(T_2^2 - T_1^2)$
		Without mass (t_o s)			With mass at d_1 (t_1 s)			With mass at d_2 (t_2 s)							
		1 (s)	2 (s)	Mean (s)	1 (s)	2 (s)	Mean (s)	1 (s)	2 (s)	Mean (s)	T_o (s)	T_1 (s)	T_2 (s)		
1	30														
2	40														
3	50														
4	60														
5	70														
6	80														

Calculation:

T_0 = ...s

T_1 = ...s

T_2 =..........s

Moment of inertia of the given disc is,

$$I_o = 2m\left(d_2^{\,2} - d_1^{\,2}\right)\frac{T_0^{\,2}}{\left(T_2^{\,2} - T_1^{\,2}\right)} =$$

Difference = [(Experimental Result - Theoretical Result)/Theoretical Result] x 100% =

Accuracy= 100% - % Difference =

Result:

The moment of inertia of the given disc is, I_0 =

Discussions:

Q: How do the length and diameter of the wire affect the period of oscillation of a torsional pendulum?

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

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

Q: Does the period of oscillation depend on the amplitude of oscillation of the cylinder?

Q: How will the period of oscillation be affected if the bob of the pendulum be made heavy?

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