Batch: D2 Roll No.: 16010221025
Experiment / assignment / tutorial No.__9__
Grade: AA / AB / BB / BC / CC / CD /DD

Signature of the Staff In-charge with date

Title– Moment of Inertia of Flywheel

Objective

To determine the moment of inertia of a flywheel.

Theory

The flywheel consists of a heavy circular disc/massive wheel fitted with a strong axle projecting on either side.The axle is mounted on ball bearings on two fixed supports. There is a small peg on the axle. One end of a cord is loosely looped around the peg and its other end carries the weight-hanger.

Let "m" be the mass of the weight hanger and hanging rings (weight assembly).When the mass "m" descends through a height "h", the loss in potential energy is

$$P_{loss} = mgh$$

The resulting gain of kinetic energy in the rotating flywheel assembly (flywheel and axle) is

$$K_{flywheel} = \frac{1}{2} I\omega^2$$

Where
I -moment of inertia of the flywheel assembly
ω-angular velocity at the instant the weight assembly touches the ground.

The gain of kinetic energy in the descending weight assembly is,

$$K_{weight} = \frac{1}{2} mv^2$$

Where v is the velocity at the instant the weight assembly touches the ground.

The work done in overcoming the friction of the bearings supporting the flywheel assembly is

$$W_{friction} = nW_f$$

Where
n - number of times the cord is wrapped around the axle

Wf - work done to overcome the frictional torque in rotating the flywheel assembly completely once

Therefore from the law of conservation of energy we get

$$P_{loss} = K_{flywheel} + K_{weight} + W_{friction} \qquad (1)$$

On substituting the values we get

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 + nW_f \qquad (2)$$

Now the kinetic energy of the flywheel assembly is expended in rotating N times against the same frictional torque. Therefore

$$NW_f = \frac{1}{2}I\omega^2 \qquad W_f = \frac{1}{2N}I\omega^2$$

and

If r is the radius of the axle, then velocity v of the weight assembly is related to r by the equation

$$v = \omega r$$

Substituting the values of v and Wf we get:

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mr^2\omega^2 + \frac{n}{N} \times \frac{1}{2}I\omega^2 \qquad (3)$$

Now solving the above equation for I

$$I = \frac{Nm}{N+n}\left(\frac{2gh}{\omega^2} - r^2\right) \qquad (4)$$

Where, I = Moment of inertia of the flywheel assembly

N = Number of rotation of the flywheel before it stopped

m = mass of the rings

n = Number of windings of the string on the axle

g = Acceleration due to gravity of the environment.

h = Height of the weight assembly from the ground.

r = Radius of the axle.

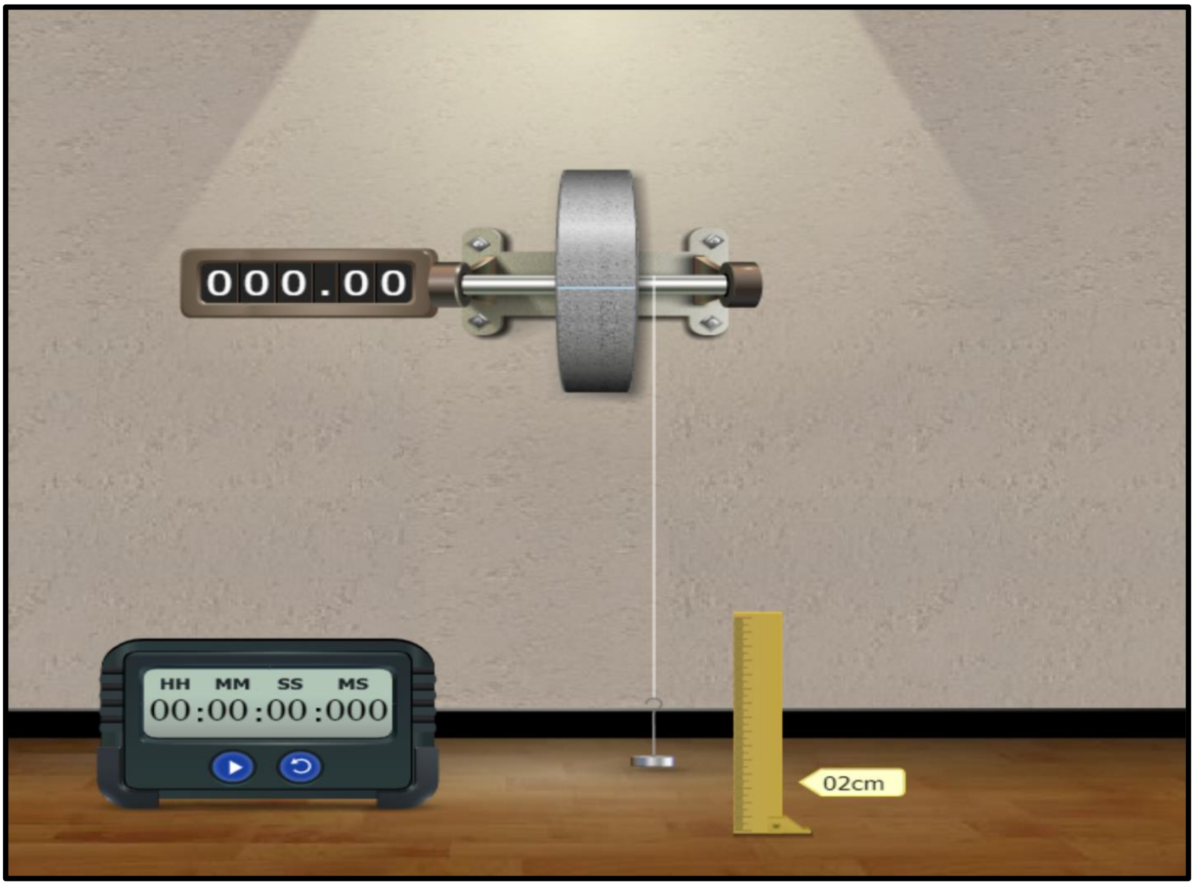
Now we begin to count the number of rotations, N until the flywheel stops and also note the duration of time t for N rotation. Therefore we can calculate the average angular velocity $\omega_{average}$ in radians per second.

$$\omega_{average} = \frac{2\pi N}{t}$$

Since we are assuming that the torsional friction Wf is constant over time and angular velocity is simply twice the average angular velocity

$$\omega = \frac{4\pi N}{t} \qquad (5)$$

Setup Diagram:

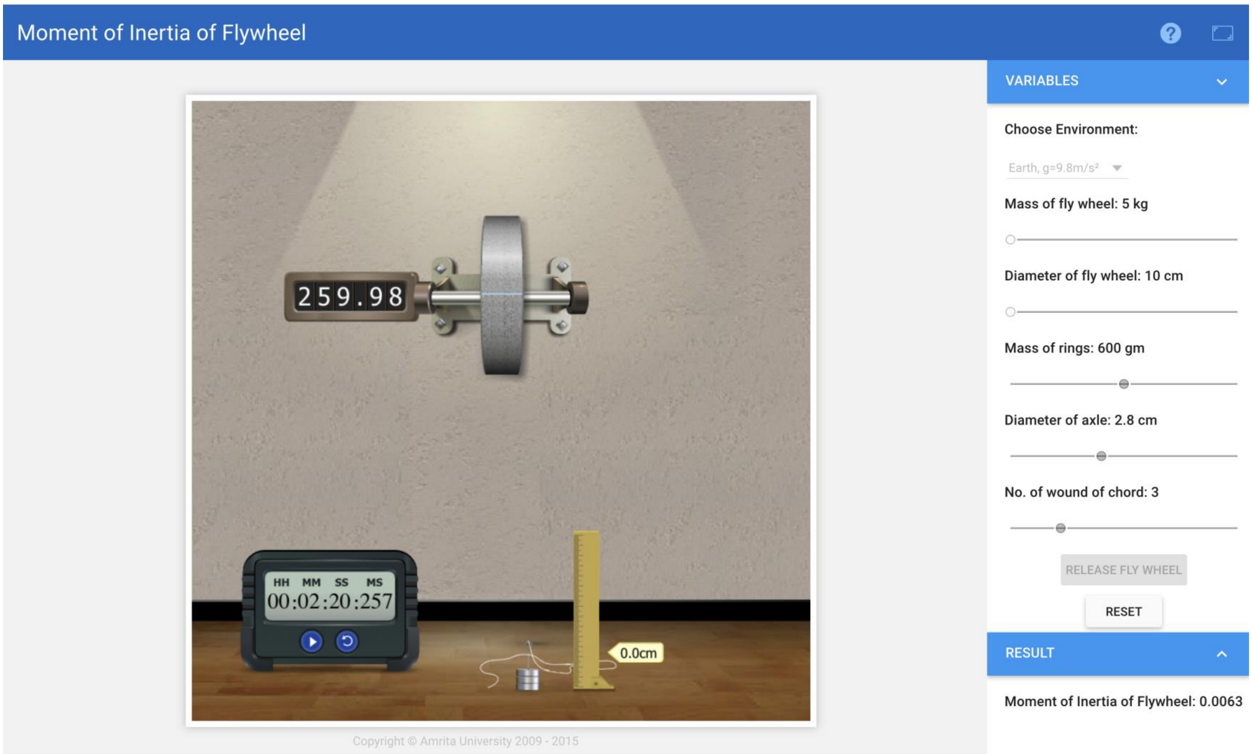


PROCEDURE:

1. Choose any desired environment by clicking on the 'combo box'.
2. Adjust the sliders to have suitable dimensions for flywheel arrangement.
3. Click on 'Release fly wheel' to start the experiment.
4. No of revolutions (N) of the flywheel, after the loop slips off from peg is indicated on the side of axle.
5. The time taken by flywheel to come to rest is noted from stop watch.
6. Repeat the experiment for different values of variables.

OBSERVATION TABLE:

Sr. No	Mass suspended (m) x 10^{-3}kg	Height above the ground (h) x 10^{-2} m	Radius of axle (r) X 10^{-2} m	Number of revolutions		Time for N revolutions (t) sec	Mean angular velocity (ω) rad/sec	MI of flywheel (Expt) Kg-m^2	MI of flywheel (Therotical) Kg-m^2
				n	N				
1	200	10	1	5	100	92s	13.654	0.00198	0.1953
2	400	8	1.2	4	178	134s	16.669	0.00221	0.00221
3	600	6	1.4	3	259	402s	8.099	0.01051	0.01055



CALCULATION:

(1.) $$\omega = \frac{4\pi N}{t} = \frac{4 \times 3.14 \times 100}{92} = 13.654 \text{ rad/sec.}$$

(2) $$\omega = \frac{4\pi N}{t} = \frac{4 \times 3.14 \times 178}{134} = 16.689 \text{ rad/sec}$$

(3.) $$\omega = \frac{4\pi N}{t} = \frac{4 \times 3.14 \times 259}{402} = 8.099 \text{ rad/sec.}$$

Conclusion:

In this experiment we calculated the moment of inertia of a flywheel.

Signature of faculty in-charge