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- POLYTECHNIC OF EGYPT -

Principle of Physics

Lab 4: Fly Wheel Experiment

© Spring 2024 - **Eng. Reem Ahmed Mostafa**
Building, office No.
Reem.ahmed@sut.edu.eg

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Objective

Calculate the moment of inertia for the given flywheel.

Equipment

- Flywheel with known mass and radius
- A string or rope
- Mass hanger
- Set of weights
- Measuring tape
- Stop watch

Theoritical Analysis

The moment of inertia (I) of an object depends on its mass distribution relative to its axis of rotation. For a flywheel with a known mass (m) and radius (R), the moment of inertia is given by the equation:

$$I = 1/2 * M R^2$$

Let's denote "m" as the combined mass of the weight hanger and the rings it carries in the weight assembly. As this mass "m" descends from a height "h," there is a reduction in potential energy.

$$U_{loss} = mgh$$

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

Theoritical Analysis

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.

Theoritical Analysis

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.

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

Therefore, from the law of conservation of energy we get

$$U_{loss} = K_{flywheel} + K_{weight} + W_{friction}$$

Theoritical Analysis

On substituting the values, we get

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

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

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

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 W_f we get:

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mr^2\omega^2 + \frac{n}{2N}I\omega^2$$

Theoritical Analysis

Now solving the above equation for I

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

$$\omega = \frac{4\pi N}{t}$$

Where: I = Moment of inertia of the flywheel assembly

N = Number of rotations 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.

Procedure

1. Measure and record the radius (R) of the flywheel's axle using a measuring tape.
2. Attach the flywheel securely to its supports, ensuring that the axle is parallel to the ground.
3. Adjust the string's length so that it's just long enough for the weight hanger to barely touch the ground and for the loop to slip off the peg (ensure the string is loosely looped around it).
4. Place an appropriate weight in the weight hanger.
5. Rotate the flywheel a specific number (n) of times, winding the cord around the axle without any overlap.
6. Measure the height (h) from the ground to the weight hanger.
7. Release the flywheel.
8. The weight hanger descends, causing the flywheel to rotate.
9. The cord slips off the peg when the weight hanger just touches the ground. By this point, the flywheel will have completed n rotations.
10. Start a stopwatch as soon as the weight hanger contacts the ground.

Procedure

11. Determine the time (t) it takes for the flywheel to come to a stop.
12. Count the number of rotations (N) the flywheel completes during this time interval.
13. Repeat the experiment while varying the values of n and m.
14. Use these collected values to calculate the moment of inertia of the flywheel using the provided equation.

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Observation

Mass suspended (m) $\times 10^{-3}$ kg	Height above the ground (h) $\times 10^{-2}$ m	No. of revolution s		Time for N revolution (t) s	Mean angular velocity $\omega = \frac{4\pi N}{t}$	Moment of inertia of the flywheel (I) $kg\, m^2$
		n	N			

Compute I from the equation

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

Conclusion

Conclusion

The computed moment of inertia

=......

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Thank You