1.0 EXPERIMENT NO: BNS/103a/06

2.0 NAME OF EXPERIMENT: Moment of Inertia of a Flywheel

3.0 OBJECTIVE: To determine the moment of inertia of a flywheel

4.0 PRINCIPLE:

According to Newton's law, F = Ma, where F is the resultant of the external forces acting on the body, 'a' is the linear acceleration of the body and M is its mass. The analogous relation for rotational acceleration is

$$\sum \tau = I\alpha \qquad (1)$$

Here $\sum \tau$ is the resultant of external torques acting on the body about the axis of rotation α is the angular acceleration and all is the moment of inertia of the body about the axis of rotation. The kinetic energy of a mass M having a linear velocity v is given by

$$K = \frac{1}{2}mv^2 \qquad (2)$$

In an analogous manner, the kinetic energy of a body of moment of inertia I and having an angular acceleration ω is given by

$$K = \frac{1}{2}I\omega^2 \qquad (3)$$

Thus, in rotational motion, the moment of inertia plays a role which is analogous to the role of mass M in linear motion. The moment of inertia of a body depends on the axis of rotation and the distribution of mass about the axis of rotation.

Equation (3) indicates that a rotating body having a large moment of inertia like a flywheel can be used to store large amounts of kinetic energy

Let a mass m be attached to the free end of a string wound around the axle of a flywheel as shown in Fig 1. Further, let r be the radius of the axle and T, the tension in the string. If the linear acceleration of mass m is a downward then by Newton's second law of motion,

$$T - mg = -ma$$

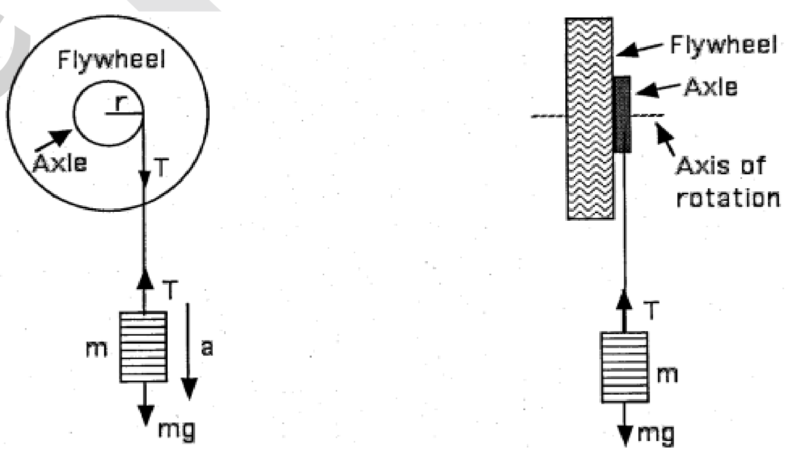
$$or\ T = m(g - a) \qquad (4)$$

The torque acting on the flywheel due to tension T in the string is given by

$$\tau = rT \qquad (5)$$

Now if τ' is the torque due to the frictional forces acting on the flywheel and if α is the angular acceleration of the flywheel, then Eq. (1) yields

$$\tau - \tau' = I\alpha \qquad (6)$$



The linear acceleration ‘a’ can be determined by measuring the time taken by the mass m to fall from rest through a distance d. In such case, $d = \frac{1}{2}at^2$, because the initial velocity is zero.

Thus, $a = \frac{2d}{t^2}$ (7)

The torque τ can be determined by using Eqs. (4) and (5), and α can be calculated by $a = r\alpha$.

By determining a number of pairs of values of τ and α (for different values of m), and by plotting a graph between τ and α, we shall get a straight line graph according to Eq. (6). Here τ' is assumed to be constant. If (τ_1, α_1) and (τ_2, α_2) are the coordinates of two points on this graph, then

$\tau_1 - \tau' = I\alpha_1$ and $\tau_2 - \tau' = I\alpha_2$.

By subtracting, we get $\tau_2 - \tau_1 = I(\alpha_2 - \alpha_1)$

Or $I = \frac{\tau_2 - \tau_1}{\alpha_2 - \alpha_1}$ (8)

If the flywheel is a circular disk of mass Ml and radius (R1, the theoretical value of its moment of inertia is given by

$I = \frac{1}{2}MR_1^1$. (9)

The radius of gyration (k) of a body of moment of inertia I and mass M is defined by the relation $I = Mk^2$.

Thus $k = \sqrt{\frac{I}{M}}$. (10)

A particle of mass M placed at a distance k from the axis of rotation will have the same moment of inertia as that of the flywheel.

5.0 PROCEDURE: (don’t write the procedure in your Lab copy)

1. Determine d, the distance of fall of mass m by measuring the length of the string.
2. Place a suitable mass on the hanger, wind the string around the axle and ‘place the hanger on the small circular platform under the flywheel.) Trip the platform and simultaneously start the timer. Stop the timer as soon as the string gets detached from the small peg on the axle.
3. Repeat step 2 by changing the mass on the hanger 4 or 5 times.
4. Measure the diameter of the axle. Record the radius and mass of the flywheel.

6.0 TOOLS/APPARATUS REQUIRED:

- A flywheel
- A timer
- A meter stick
- A hanger
- Weights

7.0 RESULTS:

Readings of the circumference of the axle:

Reading 1 =

Reading 2 =

Average circumference of the axle =

Radius of the axle, r =

Readings of the distance of fall:

Reading 1 =
Reading 2 =
Average distance of fall d =
Mass of the flywheel, M_1 =
Readings of the circumference of the flywheel:
Reading 1 =
Reading 2 =
Average circumference of the flywheel =
Average radius of the flywheel, r_1=

Readings of time of fall:

Reading No.	Falling mass m	Time of fall			
		Time t_1	Time t_2	Time t_3	Average (t)
1					
2					
3					
4					
5					
6					

Calculations:

Reading No.	Mass m	Average t	Linear acceleration 'a'	Angular acceleration α	Tension T	Torque τ

Plot a graph between α and τ.
Find the moment of inertia from the slope of the graph.
$\tau_1 =$ $\alpha_1 =$
$\tau_2 =$ α_2

Experimental value of moment of inertia,
I_{exp} =
Theoretical value of moment of inertia,
I_{th} =
Percent error =
Radius of gyration of the flywheel,
k =

8.0 DISCUSSIONS:

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to think and to mention some way out that one should adopt during the practical for getting a better result.