# LABORATORY MANUAL TO DETERMINE THE MOMENT OF INERTIA OF A FLY WHEEL

# Experiment

## Flywheel- Moment of inertia

**Aim**: To find the moment of inertia of a fly wheel.

**Apparatus**: The flywheel, weight hanger with slotted weights, stop clock, metre scale etc.

**Theory**: A flywheel is an inertial energy-storage device. It absorbs mechanical energy and serves as a reservoir, storing energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply. The main function of a fly wheel is to smoothen out variations in the speed of a shaft caused by torque fluctuations. Many machines have load patterns that cause the torque to vary over the cycle. Internal combustion engines with one or two cylinders, piston compressors, punch presses, rock crushers etc. are the systems that have fly wheel.

A flywheel is a massive wheel fitted with a strong axle projecting on either side of it. The axle is mounted on ball bearings on two fixed supports as shown in fig.b. There is a small peg inserted loosely in a hole on the axle. One end of a string is looped on the peg and the other end carries a weight hanger. A pointer is arranged close to the rim of the flywheel. To do the experiment, the length of the string is adjusted such that when the descending mass just touches the floor, the peg must detach the axle. Now a line is drawn on the rim with a chalk just below the pointer. The string is then attached to the peg and the wheel is rotated for a known number of times 'n' such that the string is wound over 'n' turns on the axle without overlapping. Now the mass m is at a height 'h' from the floor. The mass is then allowed to descend down. It exerts a torque on the axle of the flywheel. Due to this torque the flywheel rotates with an angular acceleration. Let ω be the angular velocity of the wheel when the peg just detaches the axle and W be the work done against friction per one rotation, then by law of conservation of energy,

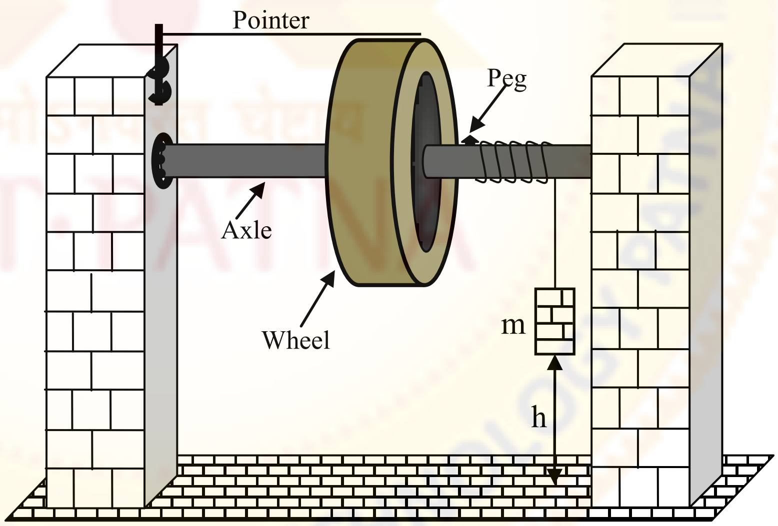


Fig.b

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

Let N be the number of rotations made by the wheel before it stops. Since the kinetic energy of rotation of the flywheel is completely dissipated when it comes to rest, we can write,

$$NW = \frac{1}{2}I\omega^2$$

Or, $$W = \frac{I\omega^2}{2N} \tag{2}$$

Using eqn.2 in eqn.1,

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 + n\frac{I\omega^2}{2N} = \frac{1}{2}I\omega^2\left(1+\frac{n}{N}\right)+\frac{1}{2}mr^2\omega^2$$

$$\therefore \quad I = \frac{Nm}{N+n}\left(\frac{2gh}{\omega^2}-r^2\right) \tag{3}$$

where, ‘r’ is the radius of the axle. To determine ‘ω’ we assume that the angular retardation of the flywheel is uniform after the mass gets detached from the axle. Then,

$$\text{Average angular velocity} = \frac{\text{Total angular displacement}}{\text{Time taken}}$$

$$\frac{\omega+0}{2} = \frac{2\pi N}{t}$$

$$\therefore \quad \omega = \frac{4\pi N}{t} \tag{4}$$

**Procedure**: To start with the experiment one end of the string is looped on the peg and a suitable weight is placed in the weight hanger. The fly wheel is rotated ‘n’ times such that the string is wound over ‘n’ turns on the axle without overlapping. The flywheel is held stationary at this position. The height ‘h’ from the floor to the bottom of the weight hanger is measured. The flywheel is then released. The mass descends down and the flywheel rotates. Start a stop watch just when the peg detaches the axle. Count the number of rotations ‘N’ made by the wheel during the time interval between the peg gets detached from the axle and when the wheel comes to rest. The time interval ‘t’ also is noted. The experiment is repeated for same ‘n’ and same mass ‘m’. The average value of ‘N’ and ‘t’ are determined. The moment of inertia ‘I’ is calculated using equations (3) and (4). The entire experiment is repeated for different values of ‘n’ and ‘m’ and the average value of I is calculated.

- Ensure that the length of the string is such that when the mass just touches the floor the peg gets detached from the axle.
- In certain wheels the peg is firmly attached to the axle. In such case, one end of the string is loosely looped around the peg such that when the mass just touches the floor the loop gets slipped off from the peg.
- ‘m’ is the sum of mass of weight hanger and the additional mass placed on it.

## Observation and tabulation

### To determine the radius of the axle using vernier calipers

Value of one main scale division (1 m s d) = ………. cm

Number of divisions on the vernier scale, x = ……….

Least count, $$L.C = \frac{\text{Value of one main scale division}}{\text{Number of divisions on the vernier scale}} = \frac{1\ \text{m s d}}{x} = \ldots\ldots\ \text{cm}$$

| Trial No. | M S R cm | V S R | D = M S R + V S R×L C cm | Mean diameter D cm |
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Diameter of the axle D = …….. cm = ……… m

Radius of the axle $r = \frac{D}{2}$ = …….. m

**Determination of moment of inertia**

| Mass suspended at one end of the string ‘m’ kg | Height from the floor to the bottom of weight hanger ‘h’ m | Number of windings of string on the axle ‘n’ | No. of rotations of the wheel after the detachment of the peg from the axle ‘N’ | | | Time interval in between the detachment of the peg and when the wheel comes to stop, ‘t’ sec. | | | $\omega = \frac{4\pi N}{t}$ | I kg.m$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | Mean N | 1 | 2 | Mean t sec | | |
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## Result

Moment of inertia of the given flywheel, I = ………. kg.m$^2$