6S3A Experiment : Moment of Inertia

Objective : To measure the angular velocity of a flywheel and calculate the moment of inertia of flywheel by the law of conservation of energy.

Apparatus : Flywheel mounted on the wall, string, slotted mass on hanger 8x50g, stop-watch, caliper and metre ruler.

Procedure and results :
1. Use a caliper to measure the diameter \(d\) of the axle of the flywheel and deduce the radius \(r\) of the axle of the flywheel. Measure the mass \(m\) of the slotted mass. Also, wind up the mass to the flywheel at a height \(h\) (approximate half metre) above the floor

   \[
   \text{Mass of the slotted mass } m = \ldots \text{ kg} \\
   \text{Height of mass } h = \ldots \text{ m} \\
   \text{Axle diameter of flywheel } d = \ldots \text{ cm} \\
   \Rightarrow \text{ Axle radius of flywheel } r = \ldots \text{ m}
   \]

2. Allow the mass to fall to the floor to make sure that the length of string is long enough to leave the flywheel when the mass reaches the floor.
3. Mark a chalk mark on the rim of the flywheel. Suppose the flywheel makes \(n_1\) revolutions before the mass reaches the floor when released.

\[\text{PQ1. Find } h \text{ in terms of } n_1 \text{ and } r\]

4. Allow the mass to fall to the floor. Measure and tabulate the result:
   (i) the time \(t\) taken by the mass to reach the floor,
   (ii) the number of rotation \(n_1\) of the flywheel before the mass reaches the floor,
   (iii) the number of rotation \(n_2\) of the flywheel before coming to rest after the mass has reached the floor.

Repeat the above steps twice to obtain three sets of data. Find the mean value of \(t, n_1\) and \(n_2\)

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<td>No. of revolutions (n_1)</td>
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<td>No. of revolutions (n_2)</td>
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Questions and result:
1. Suppose $v$ and $\omega$ are the final velocity of the mass and angular velocity of the flywheel when it reaches the floor.

Show that $V = \frac{2h}{t}$ (Hint: $S = \frac{v}{2}t$ and $v = \frac{u + v}{2}$)

**Calculate $v$ and $\omega$**

2. Consider the falling of the mass, from the law of conservation of energy

| decrease in gravitational potential | = | increase in kinetic energy | + | work done against friction |
| energy of falling mass | of mass and flywheel |

Let $W$ is the work done against friction per unit revolution.

Also, the rotational kinetic energy acquired by the flywheel is dissipated in $n_2$ revolution before coming to rest.

Show that $n_2W = \frac{1}{2}I\omega^2$

Also show that $I = mr^2\left(\frac{n_2}{n_1 + n_2}\right)\left(\frac{gt^2}{2h} - 1\right)$

**Calculate** the moment of the inertia $I$ of the flywheel.

**A practical flywheel is not a disc of uniform thickness but is a wheel with spokes with most of the mass at the rim.**

3. Compare the moment of inertia of a uniform disc with that of a wheel with spokes.

4. Compare the rotational kinetic energy stored in uniform disc with that of a wheel with spokes.

5. What does moment of inertia depend on?

6. Explain briefly how a flywheel is used in internal combustion engine to make a car receiving a more steady flow of energy.

**Reference:** Further Physics Book 1 p.136 - p.137