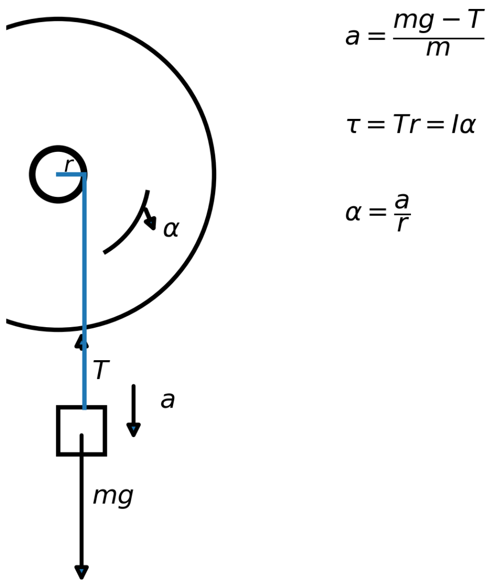

Figure 1: Caption

Determination of Moment of Inertia of a Flywheel

Aim

To determine the moment of inertia I of a flywheel about its axis of rotation.

Apparatus Required

Flywheel, light string, known weight, stopwatch, meter scale or vernier calipers.

Theory

When a torque τ acts on a rotating body, the angular acceleration α is given by

$$\tau = I\alpha$$

In this experiment, a light string is wound around the axle of the flywheel. A small mass m is attached to the free end of the string. When released, the mass descends with linear acceleration a, and the flywheel acquires angular acceleration $\alpha = \frac{a}{r}$, where r is the radius of the axle. The tension T in the string provides the torque on the flywheel:

$$\tau = Tr = I\alpha$$

For the falling mass,

$$mg - T = ma$$

Eliminating T and substituting $a = r\alpha$, we have

$$mgr - mr^2\alpha = I\alpha$$

$$\Rightarrow I = \frac{mgr - mr^2\alpha}{\alpha} = mr\left(\frac{g - r\alpha}{\alpha}\right)$$

$$\boxed{I = mr\frac{(g - r\alpha)}{\alpha}}$$

The angular acceleration α is determined from the time t taken by the falling mass to unwind the string through n revolutions before detachment:

$$\theta = 2\pi n = \frac{1}{2}\alpha t^2$$

$$\Rightarrow \boxed{\alpha = \frac{4\pi n}{t^2}}$$

Substitute this α in the above expression to obtain I.
If the frictional torque is small, it may be neglected in the first approximation.

Procedure

1. Measure the radius r of the flywheel axle using a vernier caliper or meter scale.
2. Wind a light, inextensible string around the axle and attach a known mass m to its free end.
3. Allow the mass to fall through n revolutions and record the time t taken for the fall.
4. Repeat the experiment for different values of m or n.
5. For each observation, calculate $\alpha = \dfrac{4\pi n}{t^2}$.
6. Compute $I = mr\dfrac{(g - r\alpha)}{\alpha}$ for each trial.
7. Find the mean value of I.

Observations

Sl. No.	m **(kg)**	n	t **(s)**	$\alpha = \frac{4\pi n}{t^2}$ **(rad/s^2)**	$I = \frac{mr(g-r\alpha)}{\alpha}$ **(kg m^2)**
1					
2					
3					
4					
5					
6					

Calculations

$$\alpha = \frac{4\pi n}{t^2}$$
$$I = mr\frac{(g - r\alpha)}{\alpha}$$
$$I_{\text{mean}} = \frac{\sum I_i}{N}$$

Result

$$\boxed{I = \text{...........}\ \text{kg m}^2}$$

The moment of inertia of the flywheel about its axis is determined using the above relation.

Precautions

1. The string should be light, inextensible, and wound uniformly without overlap.
2. The flywheel axle should be well-lubricated and free from wobble.
3. The falling weight should be just sufficient to overcome friction.
4. Start and stop the stopwatch accurately.
5. Repeat the readings for consistency.

Sources of Error

- Error in measurement of radius of the axle.
- Reaction time error in stopwatch operation.
- Neglecting the effect of frictional torque and air resistance.
- Non-uniform winding of the string.

1 Error Analysis

Note that $I_{mean} = \overline{I_i}$

Sl. No.	I_i	$\overline{(I_i - \overline{I_i})^2}$	$\sqrt{\overline{(I_i - \overline{I_i})^2}}$
1			
2			
3			
4			
5			
6			

Conclusion

The experiment verifies the relationship between the torque and angular acceleration of a rotating flywheel and allows the determination of its moment of inertia.