TITLE: DETERMINING ROTATIONAL INERTIA

Aim; to determine the rotational inertia of a point mass

Apparatus; Square mass, Hanger set, Pulley system, Balance, Calipers, stop watch, level, and metre rule

Theory

Theoretically, the rotational inertia, I, of a point mass is given by $I=MR^2$,where M is the mass, R the distance the mass is from the axis of rotational.

To find the rotational inertia experimentally, a known torque is applied to the object and the resulting angular acceleration is measured. Since $\tau = I\alpha$,

$$I = \frac{\tau}{\alpha} \qquad 13.1$$

Where α is the angular acceleration which is equal to a/r and τ is the torque caused by the weight hanging from the thread which is wrapped around the step pulley below the rotating platform, and

$$\tau = rT \qquad 13.2$$

Where r the radius of the step pulley about which the thread is wound and T is the tension in the thread when the apparatus is rotating. Applying Newton's second Law for the hanging mass, m gives

$$\sum F = mg - T = ma$$

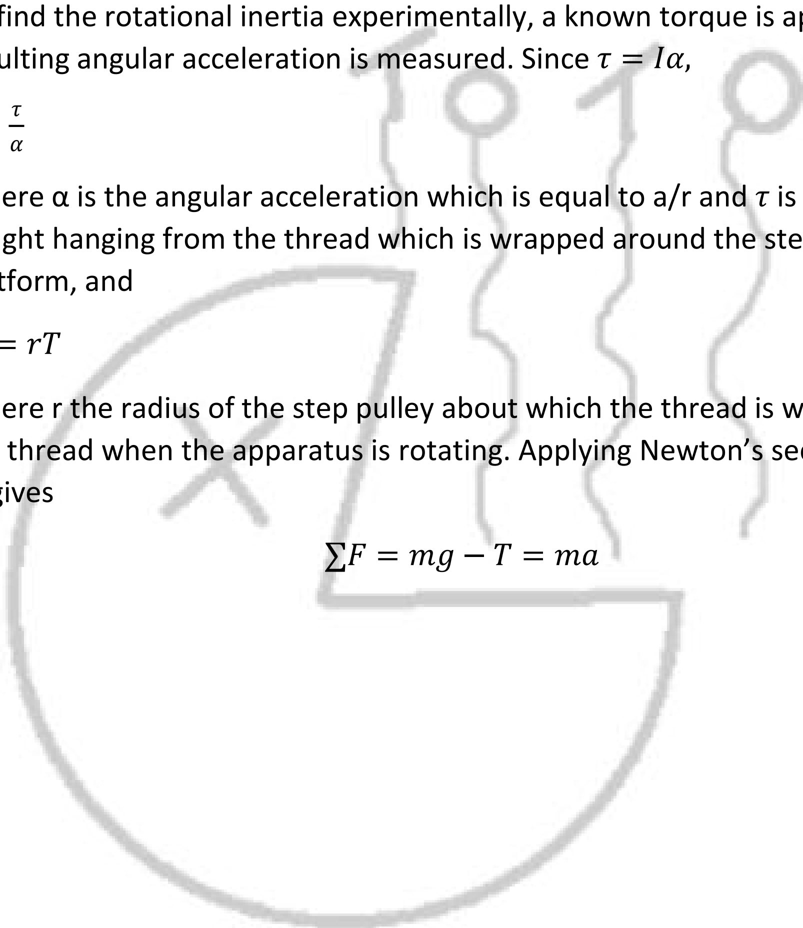

Figure 13.1

Solving the tension in the thread gives

$$T = m(g-a) \qquad 13.3$$

Once the linear acceleration of the mass (m) is determine, the torque and the angular acceleration can be obtained for the calculations of the inertia.

Procedure

Part A: Finding the friction mass

1. The apparatus was set up as shown in figure 13.1
2. The mass of the square mass was weighed and recorded
3. The rotating platform was leveled by adjusting the screws on the base (using a spirit level)
4. The square mass (point mass) was attached to the track on the rotating platform at a radius.
5. A thread was attached to the middle step of the step pulley and hanged the thread over the 10-spoke pulley
6. The string was allowed to reach the floor
7. The distance was measured from the axis of rotation to the center of the square mass and It was recorded as "R"
8. Masses were added in steps of 5g on the mass hunger until the system began to rotate. This was the mass needed to rotate the system at a constant speed; this was the mass needed to overcome friction. This mass was recorded as the friction mass "m_f".

Part B: Finding the rotating inertia

9. The friction mass on the pan was quadrupled, the thread was winded up and the rotating platform was held.
10. The platform was left to freely rotate and the time was recorded it took to fall through a height of 0.80m.This was repeated three times and the average was calculated.
11. The diameter of the second step pulley was measured using a digital vernier calipers with the thread still wound and was recorded as r.

DATA ANALYSIS

Average time

$$T_{av} = \frac{18.18 + 18.21 + 18.30}{3}$$

=18.23s

Linear acceleration

$$S = ut + 1/2at^2$$

$$a = \frac{2(s - ut)}{t^2}$$

$$a = \frac{2(0.8 - 0(18.23)}{(18.23)^2}$$

$$= \frac{1.6}{332.3}$$

=0.0048m/s²

r =28.1mm, reading taken using a digital vernier calliper

1000mm → 1m

$$28.1mm\left(\frac{m}{1000mm}\right)$$

=0.0281m

New mass (M)

$$M = M_m - M_f$$

$$= 60g - 15g$$

=45g

$$M = 45g\left(\frac{kg}{1000g}\right)$$

$$= \mathbf{0.045kg}$$

Angular Acceleration

From the theory $\alpha = \frac{a}{r}$

$$= \frac{0.0048\mathrm{m/s^2}}{0.0281\mathrm{m}}$$

=0.17m/s²

Tension in the thread

From equation 13.3 $T = m(g - a)$

$$= 0.06kg(9.8 - 0.0048)$$

$$= 0.06(9.7952)$$

$$= \mathbf{0.59}\boldsymbol{N}$$

Friction Tension

$$T_{friction} = M_f g$$

$$= 0.015 \times 9.8$$

$$= \mathbf{0.15}\boldsymbol{N}$$

Torque

From equation 13.2 $\tau = rT$

$$\tau_{net} = \tau_a - \tau_f$$

$$= (rT - rm_f g)$$

$$= r(T - m_f \mathrm{g})$$

$$= 0.0281(0.59 - 0.015 \times 9.8)$$

$$= 0.0281(0.44)$$

$$= \mathbf{0.012}\textbf{m.N}$$

Experimental rotational inertia

From equation 13.1 $I = \frac{\tau}{\alpha}$

$$I = \frac{0.012}{0.17}$$

$$= \mathbf{0.071}\textbf{kg.m}^{\mathbf{2}}$$

Theoretical Rotational Inertia

From the theory sentence one $I = MR^2$

$$= 0.045 \times 0.2^2$$

$$= \mathbf{0.0018}\textbf{kg.m}^{\mathbf{2}}$$

Percentage error

$$\%error = \frac{\bar{\delta}-\delta}{\bar{\delta}} \times 100\%$$

$$= \frac{0.071 - 0.0018}{0.071} \times 100\%$$

$$= \frac{0.069}{0.071} \times 100\%$$

$$= 0.975 \times 100\%$$

$$= \mathbf{97.5}\%$$

Answer to the Question: In calculating rotational inertia the assumption that has been made is that you need to take into consideration the friction the system experiences when carrying out the experiment**.**

DISCUSSION

Determining Rotational Inertia certain measures were taken such as leveling the rotating platform before carrying out the experiment and taking several reading; this is done so as to come up with the main value because some values are affected by systematic and random errors. In addition there were other factors that contributed to the experimental error these are: the surface were the system was standing wasn't leveled, wind, in timing the falling platform errors might have occurred and lack of a cramp stand; which was needed to cramp the metre rule when measuring the height. The difference between the Experimental Rotational Inertia and Theoretical Rotational Inertia was 0.069 and the percentage error was 97.5%.These errors can be reduced by using a surface that is leveled, using a cramp stand to cramp the meter rule and positioning the system in an area were it wont be affected by wind.

CONCLUSION

The experimental Rotational Inertia was found using the equation $I = \frac{\tau}{\alpha}$,where α is the angular acceleration which is equal to a/r and τ is the torque which is equal to $\tau = rT$.The experiment had a lot of errors which resulted in a large percentage error, despite the large experimental error the Rotational inertia was calculated.

REFERENCES

P.C. Simpemba, J. Simfukwe and G.T.Baliga *PH 110 Laboratory Manual*, (2016), School of Mathematics and Natural Sciences, Department of Physical Sciences, Copperbelt University, Kitwe, Zambia.


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