Lab Report 10:
Rotational Inertia
04/09/12

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Objective:

During this lab we will study what rotational Inertia is and how different shapes of masses and different masses behave inertially when compared to each other. We will specifically study the differences of inertia between a disk and a ring. We will use increasing forces to induce angular acceleration of both a disk and a ring of a certain mass. We will then then measure the differences in the acceleration to determine how the ring and the disk resist rotational movement. Afterward we will compare how the radius of the masses and the torque(force) applied relate to the angular acceleration. We will achieve a predictable force by using $g = gravity = 9.8$ for this acceleration.

In this experiment we will measure the inertia of a disk and a ring by dividing an applied torque by the resulting acceleration. $I = \frac{\tau}{\alpha}$. Then we will calculate the theoretical inertia using the moment of inertia equations for a disk and a ring. Then we will compare the two values and determine a percent error.

Discussion

The law of inertia states that it is the tendency of an object to resist a change in motion. Copernicus and then Galileo were the first to dispute Aristotle's thought on movement and in doing so they developed the first thoughts on inertia. Galileo Galilei was the first state “A body moving on a level surface will continue in the same direction at a constant speed unless disturbed”. Johannes Kepler was the first to look specifically at Inertia, he even gave the name which come from the latin for “laziness”. But it was Newton who echoed Gallilei with added precision and quantification buy stating that an object will remain in motion or at rest. This resistive force that objects contain is described and “Inertia”, and should be considered the single term that describes Newton’s First Law.

The rotational inertia of an object is dependent on the mass the the arrangement of the mass within the object. A simple rule of thumb is- the more compact an object's mass, the less rotational inertia an object will have. We studied to shapes and their inertia. A ring and a disk. The rotational inertia of a ring with consistent density is dependent of its mass and the inner and outer radius. The relationship between the mass and the radii is described as $I_{ring} = \frac{1}{2}M(R_1^2 + R_2^2)$. A disk is nothing but a ring with no inner radius so its inertia is simply a function of its mass and its outer radius, specifically $I_{disk} = \frac{1}{2}MR^2$.

Experimentally and inertia can be found by applying a known torque to the object and dividing that torque by the resulting acceleration. $I_{object} = \frac{\tau}{\alpha}$. We gathered this data by suspending a rotary motion sensor with its rotating axis perpendicular to the earth, thus its pulley is parallel. A second pulley was mounted with it’s axis parallel and its face perpendicular to the earth. In order run a cord downward, thus a weight could be hung from the cord to induce a force on the rotary sensor. Careful attention was given to the alignment of the two pulleys. we wanted the face of the second pulley to run tangential to the circumference of the rotary sensors pulley. If this was not achieved the force applied to the rotary sensor would actually be the $F \cdot cos(\theta)$ where theta is the angle off from ideal.

We measured and recorded the radii of the ring and disk. They were also weighed, this data was recorded. The radius of the pulley on the rotational sensor were also measured and recorded.

We attached a mass of .025 kg to the end of the cord and wound the cord up on the pulley of the rotational sensor. Just the disk was attached to the rotational sensor. Data studio was set to record velocity vs. time and the mass was released. After the mass fished accelerating data-studio was stopped and the resulting data was analysed. An acceleration was obtained by taking the slope of a best fit line of the velocity data. This procedure was repeated 3 more times with an additional .02 kg added to the descending mass each time. Next the ring was attached to the disk used above and the same measurements were taken in the same way with the same descending masses as above.

The experimental inertia was calculated using the equations above. The inertia of the disk ring combo was used to determine the inertia of just the ring by subtracting the value of the inertia of the disk.

Conclusion:

Upon my analysis our data produced constantly in accurate results. The percentage of error for both the disk and the ring was -72.59% and -71.32% respectively. I have spent much time trying to understand the source of this error. I checked the calculations used in obtaining the experimental inertia by using different methods to obtain the same value. Which was successfully done, this led me to believe my calculations were correct. I have tried altering values that might have been taken in error and I can't seem to locate of consistent source of error. I set the equation for the experimental value to the equation for the theoretical value equal to each other. I methodically solved for x in each value to check for any possible pattern error. I then noticed that If i changed the radius of the rotational sensor pulley to twice its the equations would equal. I checked the Pasco website to ensure that our measured values for the radus of this pulley was correct. It was. But then I noticed that the same thing would occur if I cut the radius of the experimental value in half.

$$\frac{(.0243m\,(.0245kg(9{,}8m/s^{2-.87\,m/s^{2}})))}{(\frac{.960\,m/s^{s}}{.0243\,m})} = \frac{1}{2}.1214kg(x)^{2}$$

$x = .049963kg \approx .5(measured\ radius\ of\ disk) \approx .5(.0943m)$

If these new values for the radius of the disk and ring are used then percent error is much lower.

I recreated Data Tabe # 4 below with the corrected values.

Run	Description	Experimental	Theoretical	% Error
#1	Ring & Disk	0.0000738 $kg\,m^{2}$	-	-
#2	Disk Alone	0.000151 $kg\,m^{2}$	0.000138 $kg\,m^{2}$	9.56
	Ring Alone	0.000587 $kg\,m^{2}$	0.000512 $kg\,m^{2}$	14.64

These errors are due to the minor variations the distribution of mass in the ring and disk. The disk was not a perfect disk, it contained several holes. Friction is also a cause of error, as is air resistance. Datastudio and its recording devices have also been known to produce errors.