Name: Sean Cornish
Lab Partners: Eli Ghattas; Zach Beatie; Will Colindres
Date: 11/29/2017

Torque and Angular Momentum

Purpose:

To learn more about the moment of inertia of different types of object by proving that objects such as disc will have a smaller rotational inertia that that of a rod with weights at the end.

Procedure:

To complete this lab, we began by setting up our apparatus. We connected a ring stand to a rotary motion sensor and connected a super pulley to the rotary motion sensor so that we could use gravity to pull on the sensor. We then attached a string to a clear plastic disc and wound it up on the sensor. We added a 20g mass to the opposite end of the string so that it would pull on the sensor and cause it to unwind. We the got several objects like a disc, block, ring, rod, and barbell and placed each one on top of the sensor one at a time, so that the falling 20g mass would cause the objects to spin as it fell. We took the mass and radius of each of those objects so that we could calculate their moments of inertia later. From there, we let the mass drop a few times and took the rotational data from the sensor. We used the data collected to calculate a theoretical and experimental moment of inertia and compared them.

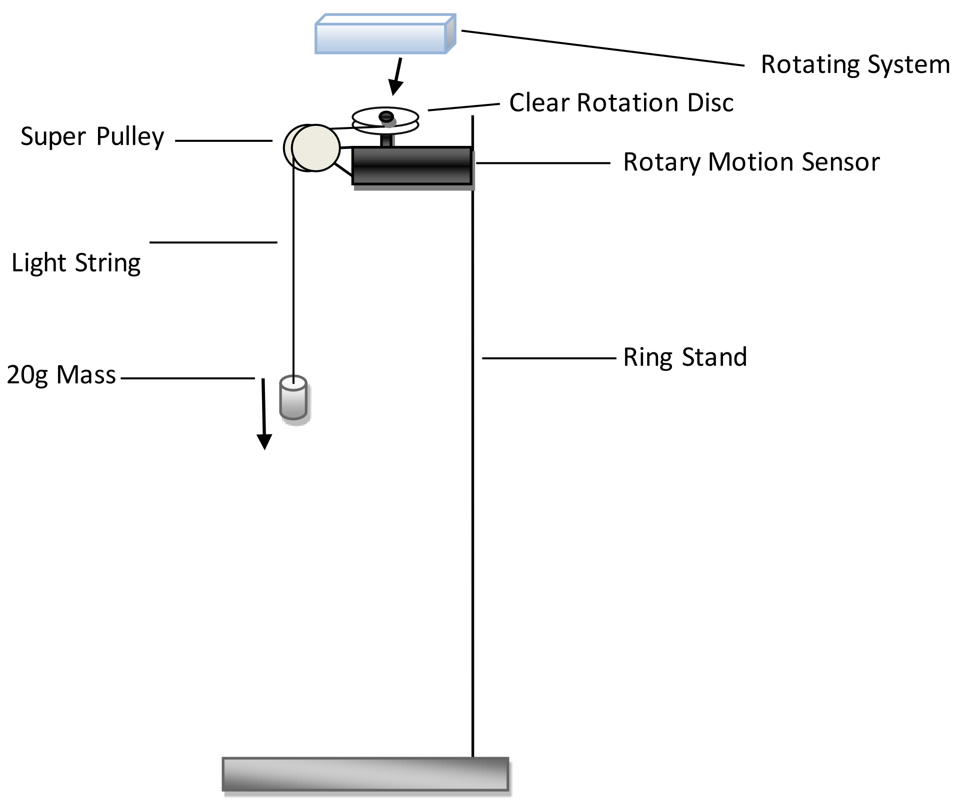

Figure 1. Equipment Setup

Table 1. Equipment

Rotary Motion Sensor
Weights
Computers
Ring Stand
Workshop 750
Super Pulley
Thin String
Paper Clips (mass hangers)
C-clamps
Disc, Ring, Barbells, and Block
Balance

Data:

Table 2. Rotating System Mass

Rotating System	**Mass** (kg)
Clear None Disc	.005
Disc	.120
Block	.6689
Rod	.0267
Barbell	.075
Screw	.002
Ring	.464

Table 3. Rotating System Radius

Rotating System	**Radius** (m)
Clear None Disc	.025
Disc	.0475
Block	.22 x .08 x .05
Rod	.375
Barbell	.375
Pulley	.025
Ring	R1=.0375 R2=.0275

Results/Analysis:

1.

Table 4. Calculated Acceleration and Experimental Moment of Inertia of Rotating System

Rotating System	**Tangential Acceleration** (m/s^2)	**Measured Moment of Inertia** ($kg \bullet m^2$)
Clear None Disc	.388	3.03×10^{-4}
Disc	.564	2.05×10^{-4}
Block + Disc	.033	1.24×10^{-1}
Rod	.308	3.85×10^{-4}
Barbell + Rod	.025	4.88×10^{-3}
Ring + Disc	.167	7.21×10^{-4}

Table 5. Experimental values of rotating systems by themselves.

Rotating System	Moment of inertia ($kg \bullet m^2$)
Disc	-0.000099
Block	0.003495
Ring	0.000516
Barbell	0.004502

2.

Table 6. Theoretical values of Moment of Inertia of Rotating systems

Rotating System	Moment of Inertia ($kg \bullet m^2$)
Disc	0.000135
Block	0.003055
Ring	0.015080
Barbell	0.021093

3.

Table 7. Percent difference between theoretical and experimental moment of Inertia

Rotating System	Percent Difference in Moment of Inertia
Disc	173%
Block	14%
Ring	97%
Barbell	79%

4. It can be seen that the friction in the bearings as well as extraneous rotating masses caused large errors in most of my measurements, but more than anything in the disc. It is likely that the disc had the greatest percent error because it is one of the lightest objects in the set of rotating systems. Because the percent error is so high, the various sources of error such as friction and misbalance have made some of the data in this lab unreliable.

Calculations:

Show all equations used, and include one sample calculation for each type of calculation performed. *Include the units all the way through the calculation, as shown below.*

1. Average acceleration (Rod)
   $a = \Delta v/\Delta t = (.27m/s-.25m/s) / (2.45s-2.4s)$
   $= (.02m/s) / (.05s)$
   $= 0.4m/s^2$

2. Experimental Moment of Inertia (Disc + Block)
   $I = MR^2(g/a-1) = (.6689kg)(.025m)^2((9.8m/s^2)/ (.033m/s^2)-1)$
   $= (.6689kg)(.000625m^2)(295.97)$
   $= 0.124kg\bullet m^2$

3. Experimental Moment of Inertia by Itself (Barbell)
   $I = [MR^2(g/a-1)]_1 - [MR^2(g/a-1)]_2 = (.00488kg\bullet m^2) - [(.075kg)(.375m)^2((9.8m/s^2)/ (.308m/s^2)-1)]$
   $= (.00488kg\bullet m^2) - (.075kg)(.1406m^2)(30.8)$
   $= .003495kg\bullet m^2$

4. Theoretical Moment of Inertia (Disc)
   $I = .5MR^2 = (.120 kg)(.0475m)^2$
   $= (.120 kg)(.00226m^2)$
   $= 0.000135kg\bullet m^2$

5. Percent Difference (Block)
   $\% = [(Experimental-Theoretical)/Theoretical]*100 = [(.003495 kg\bullet m^2)-(.003055 kg\bullet m^2)]/(.003055 kg\bullet m^2)*100$
   $= (.00044 kg\bullet m^2)/(.003055 kg\bullet m^2)*100$
   $= 0.144 * 100$
   $= 14.4\%$

Conclusion:

Throughout this lab, we were able to prove that objects with greater mass or radius have larger moments of inertia and therefore have a harder time acceleration, resulting in smaller acceleration data values. Overall, this proved that acceleration and Moment of inertia, by some factor, are inversely proportional. We accomplished our purpose because we were able to identify which objects would accelerate less by the end of the lab because of the principle that Moment of inertia is increased with both radius and mass. As can be observed in tables 2, 3, and 4, when an object had a larger mass, or a larger radius, it generally had a slower acceleration. This is because the moment of inertia of the rotational systems oppose a change in motion.

One of the major sources of error in this lab was the limitations of the instruments. As can be seen in Table 5, we have a negative moment of inertia for our disc. This is because the moment of the disc in table 4 is less than the moment of the clear none disc. This should not be because the disc was reasonably sized, however the clear none disc was much smaller and much lighter. Although the data indicates that the moment of the small clear disc is greater, we know that this cannot be true simply based on the size of the object. Another major source of error is communication. Being in a group of four people who want to finish as soon a s possible, it was easy to begin doing things that no one else knew we were doing. This caused some of us to record differing data and also could be the reason for the incorrect data in table 4 as mentioned previously. I believe that this is why we have such high percent errors in table 7. Especially with the disc having over 100% error we need to make a change. In order to improve the lab, I would have the groups have assigned positions so that each member knows what they ought to be doing at any given time, and have one of those jobs be to check if the data is reasonable. Another way to improve the lab is to split the class into smaller groups so that communication can be clearer and all partners will have the ability to make sure that what is going on in the experiment is reasonable and correct. Hopefully next time, these precautions could lower the margin of error.