Physics 118 - Studio 22 Analysis

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Analysis

We attempt to measure the moment of inertia of three contiguous rotating disks each with a different radius by applying some easily calculable torque and measuring the resulting rotation.

Moment of inertia of the disk system, assuming uniform density, is going to be given by

$$I_{disk} = \frac{M}{8} \frac{\Sigma_i L_i D_i^4}{\Sigma_i L_i D_i^2}$$

Where L is a disk's length, D is a disk's diameter, and M is the mass of the disk system. We are given the necessary values and their uncertainties (units are in meters unless specified):

Mupper (kg)	L1upper	L2upper	L3upper	D1upper	D2upper	D3upper
5	2.54E-2	2.59E-2	2.55E-2	7.65E-2	0.1535	5.09E-2
Mlower (kg)	L1lower	L2lower	L3lower	D1lower	D2lower	D3lower
4.8	2.52E-2	2.57E-2	2.53E-2	7.63E-2	0.153	5.07E-2

Thus, we find the moment of inertia of the entire wheel to be: $(0.01142 \pm 0.00026)kgm^2$. By examining the components of the I_{disk} sum listed above, we see that the second disk (D_2 and L_2) contribute about an order of magnitude more to the moment of inertia than the other two disks, while disk 1 contributes about twice as much as disk 3.

Experimentally, we measured the mass, time taken, and distance fallen of the mass when attaching a it to one of our disks. We were given the radius and derived the mass' acceleration and the remainder of the table:

mass(kg)	mass' accel(m/s^2)	radius(m)	dist fell(m)	time taken(s)	m(g-a)R(kgm^2s^2)	a/R ($m/s^2/m$)
0.5	0.24	2.54E-2	0.705	2.38	0.12	9.8
0.5	2.7	7.665E-2	0.705	0.72	0.27	35.4
1	1.3	3.82E-2	0.7045	1.04	0.32	34.1
1	3.6	7.665E-2	0.705	0.62	0.47	47.8
0.2	5.5 E-2	2.54E-2	0.705	5.03	4.95E-2	2.19

Plotting $m(g-a)R$ vs a/R , we achieve: This slope, gives us an experimental estimate of the moment

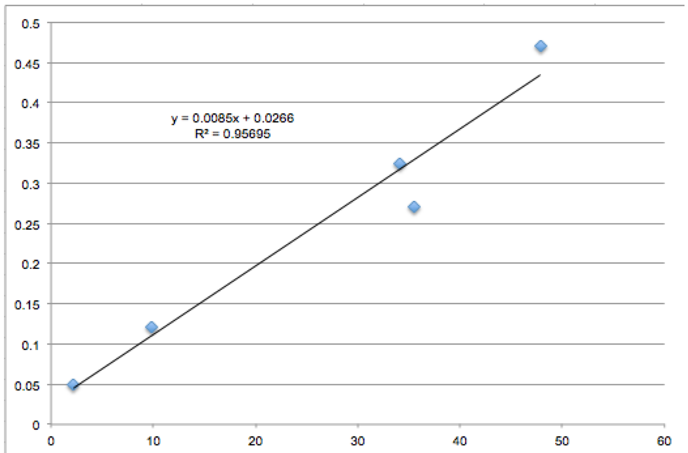

Figure 1: Graphical extraction of moment of inertia

of inertia. We see this because we know that $m(g-a)R$ should be equal to something (moment of inertia) times a/R + the frictional torque, so plotting the two against each other and calculating the approximate slope will result in the moment of inertia. Thus, our experimental moment of inertia is $.0085 \pm .0011 kgm^2$. The y-intercept of this plot, $.0266 \pm .0024$, represents the frictional torque of the wheel in our experiment across our trials (in newtons). Unfortunately, the experimental ($.0085 \pm .0011 kgm^2$) and theoretical (0.01142 ± 0.00026) results do not agree, as their margins of error do not overlap. This could be due to unexpected friction, or other human error during experimentation. Our frictional force of $.0266 \pm .0024$N makes sense, because this force is small compared to the force of gravity on the masses that we used.