MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

Physics 8.01 Fall Term 2007

Experiment 05: Angular Momemtum

Section and Group: 13A

Participants: David Litster

Each group need turn in only one report.

Part I: Calibration

Give the generator calibration (in $s^{-1}\,V^{-1}$) and its standard deviation for your apparatus.

I found the calibration coefficient to be 69.2 s^{-1} V^{-1} with a standard deviation of 0.3.

Moment of Inertia

Fill in the table below with the values you found when calibrating your apparatus.

α_1 (s^{-2})	α_2 (s^{-2})	$\mathcal{I}_R$ ($kg\,m^2$)	Std Dev	τ_f (N m)
88.7	-31.2	0.000050	0.000001	0.0016

Variation of Friction Torque with ω

Fill in the table below with the values you found from a long coast.

ω_{fast} (s^{-1})	$\|\alpha\|$ (s^{-2})	$\tau_{f\,\text{fast}}$ ($N\,m$)	ω_{slow} (s^{-1})	$\|\alpha\|$ (s^{-2})	$\tau_{f\,\text{slow}}$ ($N\,m$)
450	51.2	0.0026	100	32.8	0.0016

Part IIA: Slow Collision

Type of collision (fur-on-fur or brass-on-fur): *fur-on-fur*

$\mathcal{I}_R$ (from Part I): 0.000050 kg m^2 $\mathcal{I}_W$ (washer you dropped) 0.000047 kg m^2

Fill in the tables below with the values you found in your experiment.

ω_1 (s^{-1})	ω_2 (s^{-1})	δt (s)	α_R (s^{-2})	α_W (s^{-2})
280	135	0.524	-277	258

$\lvert\alpha\rvert_{f\,\text{coll}}$ (s^{-2})	$\tau_{f\,\text{coll}}$ (N m)	$\mathcal{I}_R\,\omega_1$ (kg m^2/s)	$\mathcal{J}_{f\,\text{coll}}$ (N m s)	$(\mathcal{I}_R + \mathcal{I}_W)\,\omega_2$
36.8	0.00184	0.014	0.001	0.013

1. Do the data in the above table confirm the conservation of angular momentum after correcting for the impulse of the friction torque?

Yes, they do. The original angular momentum minus the impulse equals the final angular momentum.

2. Assuming constant angular acceleration, how many radians did the rotor rotate during the collision?

$\theta_R = \omega_1\,\delta t + \frac{1}{2}\alpha_R\,\delta t^2 =$ 108.7 radians.

3. Assuming constant angular acceleration, how many radians did the washer rotate during the collision?

$\theta_W = \frac{1}{2}\alpha_W\,\delta t^2 =$ 35.4 radians.

4. How much did the washer slide on the rotor during the collision?

108.7 - 35.4 = 73.3 radians or 11.7 revolutions.

Part Two: Fast Collision

Read ω_1 and ω_2 (the values of ω_R before and after the collision) from your graph and write them into the table below. (Take "after" to be the time when oscillations are no longer visible.) Calculate the angular momentum before and after the collision and put those values in the table as well.

ω_1 (s^{-1})	$\mathcal{I}_R\,\omega_1$ (kg m^2/s)	ω_2 (s^{-1})	$(\mathcal{I}_R + \mathcal{I}_W)\,\omega_2$
280	0.014	148	0.014

1. How much kinetic energy was lost over the entire course of the fast collision?

   $\frac{1}{2} \times 0.000050 \times 280^2 - \frac{1}{2} \times 0.000097 \times 148^2 = 1.96 - 1.06 = 0.90$ joules.

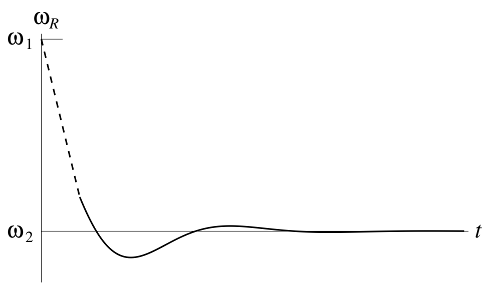
2. What value did you measure for $\omega_{R\,\mathrm{min}}$ (the value of ω_R at the bottom of the dip)?

   $131\ s^{-1}$

Note: For the remaining two questions you may assume $\mathcal{I}_W = \mathcal{I}_R$.

3. Use the conservation of momentum to find ω_W when $\omega_R = \omega_{R\,\mathrm{min}}$.

   $(148 - 131) + 148 = 165\ s^{-1}$



4. Assuming the model represented by the sketch above is correct, how much kinetic energy was contained in the oscillatory motion of the washer with respect to the rotor at the time when $\omega_R = \omega_{R\,\mathrm{min}}$?

   $2 \times \frac{1}{2} \times 0.000050 \times (148 - 131)^2 = 0.000050 \times 17^2 = 0.014$ joules.