PHYSICS 125 EXPERIMENT NO. 8
CONSERVATION OF ANGULAR MOMENTUM

Introduction:
In this experiment we study torque, moment of inertia, and angular momentum conservation with a rotating platform.

Equipment:
One rotating platform with photogate, one pulley with clamp, one iron disk with handle, one interface box, one computer with timing program, small masses, vernier caliper.

Method:
Observing the angular momentum of an object, the rotating platform, under an external torque will enable us to measure the moment of inertia of the object using the equation

$$\tau_{external} = I\alpha,$$

where $\tau_{external}$ is the net external torque, α is the angular acceleration, and I is the moment of inertia. After the moment of inertia is determined, conservation of angular momentum will be investigated. We drop a mass onto the rotating platform and measure the angular velocity, ω before and after the "drop". We test angular momentum conservation using the relation

$$I_i\omega_i = I_f\omega_f,$$

where i and f standard for initial and final.

Procedure:
1. **CORRECTION FOR SYSTEMATIC ERROR, FRICTION:** Unlike the motion of the glider on tile air track, the rotating table does exhibit significant friction. After starting rotation, the table will slow down and eventually stop. This effect, however, can be taken into account by a preliminary experiment.
Connect the photogate to the interface box and set up the computer in MOTION TIMER mode (see procedure 3. to 5. in lab “Acceleration"). Measure the angular velocity, ω of the freely turning table for 20 or 30 seconds. When the distance between timings is requested, enter the angular distance (in radians) between the pieces of tape on the plastic ring that pass through the photogate. The velocities will then be in radians/sec.

Graph ω vs. t in your lab book, fit a best line through your data points and calculate the angular acceleration (deceleration actually), α_{fric}, due to the frictional torque.
Is the frictional torque dependent on the velocity?

2. **MEASUREMENT OF MOMENT OF INERTIA,** I: Using a vernier caliper, measure the diameter of the cylinder under the rotating table to which the string will be attached. Attach a mass to the free end of the string, and wind the string neatly around the cylinder. Loop the string over the pulley and release the mass. Record angular velocities as above and calculate the angular acceleration, α. Calculate the moment of inertia, I from the equation

$$I = \frac{m(g - R\alpha)R}{|\alpha_{fric}| + \alpha},$$

where m is the mass at the end of the string and R is the cylinder radius.
Derive this equation.
Repeat the experiment with another mass.

3. **CONSERVATION OF ANGULAR MOMENTUM:** Remove the string from the rotating table and set the table in motion. Record the initial angular velocity, ω_i. Drop the iron disk onto the table from a small height (less than 1 cm) above the table, so that the rim of the disk matches the rim of the table as closely as possible. Record the final angular velocity, ω_f. Given the mass, M, of the iron disk and measuring its radius r, calculate its moment of inertia using $I = 1/2\ Mr^2$

Compare the initial angular momentum of the table/disk system $I_i\omega_i$ with the final angular momentum after the drop, $I_f\omega_f$. Determine whether your experiment (within its error limits) confirms angular momentum conservation.

Questions:

What assumptions are your calculations of the moment of inertia based on? If you drop the disk a couple of cm off center, what effect will this have on your result? Explain qualitatively.