Experiment 3: Collisions

3.C. Rotational Coupling Collision

This week you will complete your study of collisions by considering a collision between objects that are rotating. The focus will shift to comparisons of the total angular momentum and rotational kinetic energy before and after the collision.

Equipment/supplies provided:

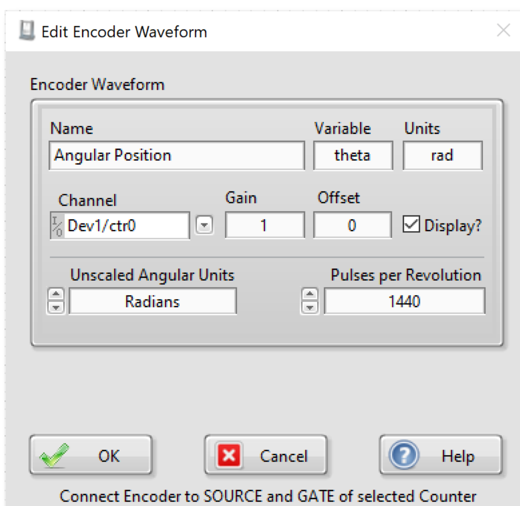
- Rotary encoder, interface box, and computer.
- Rotational apparatus.

Experimental Tasks:

1. ***Measure the angular momentum and rotational kinetic energy before and after an axial coupling collision.***

   1.1. The rotational apparatus consists of a disk mounted on a low-friction axle and a ring that can be dropped onto the disk. Measure the physical parameters of the disk and the ring and use tables of rotational inertia for different shapes to calculate the rotational inertia of each. Be careful with the units; express the rotational inertia in kg·m^2.

   1.2. In Lab Assistant, set up the rotary encoder to measure the angular position of the rotating disk in radians as shown below. Verify the sensor is working properly by acquiring data while rotating the disk through one revolution and then back again to where it started. If the angular position reported does not increase to 2π radians and then back to zero as expected, then check with an instructor for help.



   1.3. Add a derived waveform channel for the angular velocity of the disk computed as the derivative of the angular position.

   1.4. Spin the disk, begin acquiring data with Lab Assistant, and after a few seconds carefully drop the ring onto the disk so that it is centered on the axle and lands in the groove on the disk. When finished, observe the angular velocity waveform and identify three distinct time intervals: before the collision, during the collision, and after the collision.

1.5. Use the cursor tool to extract the values of the angular velocity immediately before the collision and immediately after the collision. Using the values of rotational inertia, find the initial angular momentum L_i of the system when only the disk is spinning and the final angular momentum L_f when both the disk and the ring are spinning. Does it appear that the angular momentum of the system is conserved?

1.6. Compute the rotational kinetic energies of the system immediately before (K_i) and immediately after (K_f) the collision. Is the rotational kinetic energy of the system conserved? Compare the ratio K_f/K_i to the value

$$\frac{K_f}{K_i} = \frac{I_{DISK}}{I_{DISK} + I_{RING}}$$

predicted from the pre-lab question.

2. Model the rotational coupling collision in VPython.

2.1. Obtain the starter code for this model from physics.wku.edu/up/phys256/ and use it to create a new VPython program.

2.2. Be sure that the physical parameters of the system (masses and radii) are set to the correct values.

2.3. Notice that the collision is modeled using a frictional torque that acts on the ring (by the disk) and an equal and opposite torque that acts on the disk (by the ring). This torque acts from the moment the ring is dropped until the angular velocities of the two objects are the same (and they are moving together). Also notice that the intervals before and after the collision are modelled assuming a small frictional torque (due to the axle bearings not being perfect) acts on the system. Estimate these values from your data. You will need to add code that will update the angular momentum of the system in each interval, before, during, and after the collision. Attempt to adjust your model so that it closely reproduces your data.

For Next Week

Bring a draft report that encompasses the three collisions experiments. Your report should include the sections: introduction, experimental description, data, analysis, and conclusions.