

THIS EXPERIMENT NEEDS CHECKING AND A DATA TABLE

EXPERIMENT 10: CONSERVATION OF ANGULAR MOMENTUM

In continuing our study of angular motion, we turn next to the study of momentum as it applies to angular motion. We will use again the “Rotational Dynamics Apparatus” used in the last experiment. This apparatus allows us to study a variety of collisions, for example between two rotating disks, or between a ball with linear motion and a catcher mounted on one of the disks.

BACKGROUND

You should review the definition of angular momentum in sections 11-4, 11-7 and 11-8 of the textbook. In particular, pay attention to Sample Problem 11-8, which shows how an angular momentum is calculated for an object moving with straight line motion. Also note in section 11-12 the expression $L = I\omega$, useful for calculating the angular momentum of a rigid body about a fixed axis.

PROCEDURE A

1. The first collision you will do involves a completely inelastic collision between two disks or cylinders, rotating about their common axis of symmetry. Since there is only one apparatus, the masses of the two disks will be measured before class and the result posted on the board. From these masses and the radius of the disks, you should calculate the rotational inertia of the disks and place the values in the data table. The radius may be measured from a third disk of identical diameter on the side table, or you may use the radius from the last experiment.
2. The two disks can be made to rotate independently by placing a pin in the central axis opening. This forces air to escape between the two disks. Closing the tube under the platform of the apparatus, either by holding it closed with your finger or pinching the tube shut with a clamp allows the bottom disk to rotate on a cushion of air. Thus the two disks rotate independently. When the pin is removed, the air escapes through this hole, and the two disks rotate together, thus accomplishing a completely inelastic collision.
3. You will use the computer to record the angular velocities before and after the collision. If you are setting up the computer, choose “Rotational Dynamics, Old Method” near the end of the options list when presented with options after dragging the icon for the plug onto digital channel one. Next, accept the default settings of 200 bars by clicking OK.
4. Now, drag the icon for Table onto the digital channel one box, and highlight “angular velocity” to be displayed.
5. With the computer and data tables set up, turn the air on, to approximately 9 psi, and make the two disks rotate in opposite directions, preferably with the bottom disk rotating faster in the clockwise direction. Then click “Rec” on the experiment set up window. Allow the disks to rotate for a half-minute or so, so the computer will

record the initial angular velocities. Then pull the pin, and record data for a half-minute after the disks are seen to be rotating with a constant angular velocity.

- Note the direction of the final angular velocity, clockwise or counter-clockwise. Record the velocities on your data table, with the proper sign (clockwise is negative, counter-clockwise is positive). Now return to your table and do some of the calculations, or measurements. Place calculated values of L_o , and L on Data Table 1 while you are waiting your turn, or after finishing the first part of the experiment and while other students are doing the first part.

PROCEDURE B

- Measure the mass of the ball which will be used in the second example of completely inelastic collision and record in Data Table 2.
- You will make the next measurement needed on a second computer, on the side table on the south wall of the lab (the opposite side of the lab as the “Rotational Dynamics Apparatus” and its computer). Connect two photocells into digital channels one and two and place them with their bases touching next to each other at the bottom of the ramp which the ball will slide down. In this manner, during its horizontal travel the ball will pass through both photocells, after it rolls down the ramp. The second photocell may need to be a little lower, if the ball has already left the ramp. The object is to have the middle of the ball at the level of the light source and photocell receptor.
- Drag the symbol for the plug onto digital channel one on the experimental window, and select “photocells (2)”. Measure the diameter of the ball and the distance from one edge of the base of one photocell to the same edge of the base of the next photocell. This last measured distance is the distance between gates. Enter these two dimensions as “object length” and “spacing between gates”, respectively.
- Next, drag the table icon onto digital channel one and select velocity between gates 1 and 2.
- Adjust the gates a little and make repeat measurements of v ; you should take the largest velocity you get and record it in the data table. You want the largest velocity because if the ball is not centered in the photocell range, a longer time will be recorded, giving a too small velocity. Each time before you release the ball at the top of the ramp, you should hold it balanced on the point of the top, and then release it. Record the velocity you measure in Data Table 2.

PROCEDURE C

- You now need to determine the rotational inertia, I , of the disk and ball catcher. You will do this by the same method you used in the last experiment. With the ball catcher attached to the top disk, attach the 25 g weight to the string and the pulley under the catcher. Now, if necessary delete the table previously selected for velocity and select a new one for angular acceleration (by dragging the table icon onto Digital Channel one and highlighting acceleration).

13. As you did in the last experiment, allow the weight to fall while recording data, and record the angular acceleration onto Data Table 3. Calculate I while you wait your turn for the last part of the experiment.

PROCEDURE D

14. Set the computer to record angular velocity. Place the ramp on the weights taped to the rotational dynamics table. Turn the air on and put the catcher at the bottom of the ramp. Start recording, and release the ball from the top of the ramp. Repeat two times and record the three resulting angular velocities on Data Table 3. Also each time record r , the location of the ball from the axis of rotation, in cm, using the metric tape on top of the catcher.
15. Calculate I_0 and L , using the average values of r and ω , and a percent difference. Enter all values in Data Table 3.

QUESTIONS

1. In procedure 11 it was mentioned that the photocells need to be aligned properly to get a correct speed reading. Show with a sketch what happens if the second photocell is too high, for example if it is at exactly the same level as the first, while the ball is falling a slight vertical distance.
2. Calculate the percent of kinetic energy lost during each of the inelastic collisions. Compare the percent lost with the “elastic” and inelastic collision of the two dimensional collisions from two experiments ago.

