EXPERIMENT 8: CONSERVATION OF MOMENTUM, TWO DIMENSIONS

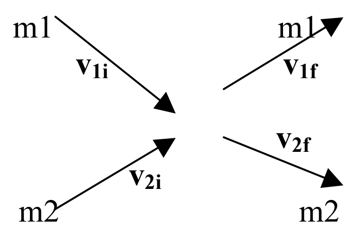
In this experiment we continue our verification of the conservation of momentum, this time in two dimensions. We will use a flat table, called an air table. Two round objects (pucks) will float on the table supported by a cushion of air. As in an earlier experiment, we will use a high voltage power supply to cause a spark to jump and leave black dots on paper, which will indicate the positions of the two pucks, every 0.100 s.

BACKGROUND

If you have not already done so, you should read section 9-7 and 9-11 in your text, paying especial attention to Figure 9-22, which shows something similar to the first part of the experiment you will do here. Analysis of the conservation of momentum requires knowledge of velocity, both speed and direction, of each object. This information we obtain from the lines of black dots left by the pucks on the paper.

ADVANCE STUDY ASSIGNMENT

1. For the sketch at right, take the x-axis to be parallel to the $\mathbf{v}_{1i}$ velocity vector, with the y-axis at the usual 90º angle. Draw the x-y axes on the sketch. What are approximate angles for the other three velocity vectors? (Give answers such as 30º, -90º, 135º and label them θ_{1i} , θ_{2i} , etc.)
2. Draw in velocity vectors for the COM of the masses sketched at right, assuming all masses are equal.



PROCEDURE A

1. Place a fresh piece of paper on the table. Use a small piece of tape to hold down one corner. Next smooth the paper and place a piece of tape in the opposite corner. Then smooth out the paper and place pieces of tape in the remaining corners. The goal is to prevent any ripples in the paper, which would introduce unwanted friction.
2. Place the pucks in the center of the table; ensure the tubes are not twisted and see that the table is level (or nearly so). Now move the pucks to the two near corners, and practice making them collide by giving them a short push towards the center, touching the insulating handles, not the metal pucks. A short push is necessary so you are not accelerating the pucks during the time we will measure displacement to calculate the velocity.
3. Now, with the two pucks in the near corners, briefly test the spark generator, by closing the switch and listening for the clicks. This will also put some dots under the pucks, so you know which corner the pucks start from.
4. One partner should hold the switch closed while the other partner pushes the two pucks toward the center and a collision. Continue to hold the switch closed until after both pucks have hit the side walls of the table, but release the switch as soon as the second puck hits the wall.

5. Now remove the paper from the table. Make sure you have tracks of the pucks paths, with the collision near the center. All tape should be removed from the table, and from the paper. Take the paper to your table and start analyzing data. You should use about a 10 cm length of track, close to the collision, to measure a displacement for the purpose of calculating velocity for each of the 4 velocities associated with the collision (1i, 1f, 2i, 2f). The number of intervals you use is not important, as long as the length is near 10 cm (shorter, and normal measurement limitations become a substantial percent of the displacement; longer, and the effect of friction is larger). Indicate the number of intervals used on your data table, as N, and record the lengths on the data table. Lengths should be measured to .01 cm (XX.XXcm).
6. Choose, arbitrarily, to call the $\mathbf{v}_{1i}$ direction the positive x-axis direction. Thus θ_{1i} will be 0° by definition. Measure the remaining three angles, being careful to determine the correct angle to measure. It will probably be useful to sketch an x-y coordinate system near the line of dots for $\mathbf{v}_{1i}$, and then think of placing each other vector in turn on the origin, to help you decide what the approximate angle is. The angles are measured with a protractor. If lines you want to measure angles between do not intersect, then draw parallel lines using the width of your ruler. Angles should be measured to 0.1°. Record all angles on the data table.
7. Fill in the remainder of the data table by calculating the momenta values, and then the vector momentum values before and after the collision. In your calculation section (remember you are showing one sample calculation for each type), show the calculation of the vector momentum, using the vector capabilities of your calculator. If you do not have a vector capable calculator, borrow a classmate's, or borrow the instructor's. Finally, calculate the percent differences between the magnitudes and the angles of the initial and final momenta values. Show calculations and place results in the data table.

PROCEDURE B

8. For the second collision, we will use the same pucks, this time with a velcro skirt on the pucks, so they will stick together after the collision. One problem is that the pair of pucks sometimes rotates after the collision. In this case we need to use their center of mass for making displacement measurements. To do this, circle the first pair of dots after the collision, and then circle every second or third dot, depending how close together your dots are. Now, with a ruler, place a dot, and circle it, at the center of mass (COM) of the two pucks. Notice the shape of the line connecting the COM points.
9. Make the same measurements and calculations as for the elastic collision, except now you have only one set of measurements after the collision, for $(m_1 + m_2)$.

PROCEDURE C

10. The last part of the experiment is to determine how much friction might affect the results. Pick the longer trail after the collision from the first part of the experiment. Measure the length of 3 intervals closest to the collision, and farthest from the collision, but before the puck hits the side rail.

QUESTIONS

1. From results of Procedure 3, does it seem likely that friction is negligible? Explain, using reference to your data in Data Table C.
2. Calculate the kinetic energy before collision and after collision from Data Tables A and B. Is there any difference in the two cases? Calculate the percent of kinetic energy lost in each collision, and comment on the ideas of elastic and inelastic collisions.
3. What was the shape of the two paths after the inelastic collision? (Straight lines or curves?) What was the shape of the dots representing the COM of the two masses after the collision