EXPERIMENT 7: CONSERVATION OF MOMENTUM
(ONE DIMENSION)

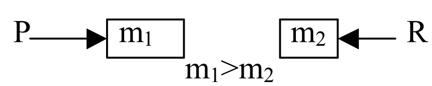
In many cases, external forces are small enough that they may be ignored, or else all of the external forces cancel. In these cases, momentum should be conserved, as we studied in Chapter 9. In this experiment we will attempt to verify this conservation law while studying various collisions.

BACKGROUND

In this case we will use an air track to minimize friction effects. We will study one-dimensional (nearly) elastic and completely inelastic collisions. For the elastic collisions, the equations derived in your textbook, 9-9 should apply. Observe that, when the air supply is turned on, a slight push will propel the glider car for two or three lengths of the track, with collisions at either end. (Compare this with the notable remaining friction of the 2-meter metal track used in the friction experiment, Experiment 6.) We will use photocells (also called photogates) to time the gliders traveling on the air track. This time and the length of the gliders will allow us to calculate the velocity, and then the momentum.

ADVANCE STUDY ASSIGNMENT

1. What is meant by a conservation law?
2. What is the requirement for conservation of momentum?
3. 2 masses on a frictionless table are hold in position by a pair of forces P and R, as a compressed spring pushes them apart.
   a) Compare forces P and R.
   b) If forces P and R are suddenly removed, what happens to m_1 and m_2?
   c) Compare the momenta of m_1 and m_2 after the spring pushes them apart.



PROCEDURE A

1. First, you should check that friction is small. Do this by putting the three gliders on the track. Push each one, and observe how far it travels (with the air turned on). If each travels only a short distance, then you need to check the air supply or the balance of the track, in the horizontal direction perpendicular to its length. This is adjusted by adjusting the height of the legs on the end of the track with two legs. If only one of the three gliders stops short, then most likely that glider is defective, and should be replaced.
2. You will need to level the track in its long direction, by placing gliders at either end of the track, and one more in the middle. The track is leveled by adjusting the feet, turning the screws in or out of the base. If necessary, small coins or books may also be placed under the feet. Check again the levelness of the perpendicular direction to the length of the track. Ideally all the gliders should remain where placed when the

track is level. Unfortunately, because the tracks were stored for 20 years standing on their legs, they have sagged, so the middle is slightly lower than the edges. Thus, the best you can do is have the glider in the middle stationary, and the gliders at either end accelerate slightly towards the center. (For the last 5 years the tracks have been stored upside down. This is an experiment to see if some of the sag will be reversed. Unfortunately, we may have to wait another 5 or more years to see the result of the experiment.)

3. When the track is level, or as close as you can get it, place two photocell gates near the center of the track, with a distance between them equal to a little less than four times the length of the longer glider.
4. Now open Data Studio on the computer, click on “Create an Experiment” and then click on the Sensors Button, immediately under the words “Experiment Setup” on the setup window. Plug the photocells (or photogates) into the computer interface and select “Photogate” twice (by double clicking) from the Experiment Setup. A photogate icon should appear in the window.
5. Click on Timers button in Experiment Setup. On Timer 1, choose Ch 1 blocked and then Ch 1 unblocked after clicking the down arrow next to Ch 1 icon. Next click on “New” on the button on the Timers window, and then select Ch 2 blocked and Ch 2 unblocked for Timer 2. Finally, click DONE. On Data window (to left of experiment setup window), click and hold on Timer 1 and drag it to Table (on the display window below the data window, to allow it to display a table). For Timer 2, do the same.
6. Move both gliders through the photocells slowly (only with the air turned on – sliding the gliders on the track without the air supply on may scratch the track). Note that when the gliders block the photocell, the light on top of the photocell comes on. Adjust the height of the photocells so the gliders (including the spring) pass through the photocells without rubbing. Also make sure the glider (and not just the screw heads on top of them) is blocking the photocell.
7. Record the mass and length of the gliders (m1, m2 and m3) in Data Tables A and B. m1 is the larger glider with the spring. m2 is the large glider without a spring, and m3 is the smaller glider. Record also the length of the three gliders.
8. The first collision you will study is an “elastic” collision between m1 and m2, with m1 hitting m2 initially at rest. Practice and observe that collisions occur completely within the space between the two photogates. When you are ready, click “Start” and hold m2 still between the photogates, and then push m1 through the first gate to hit m2. Click “Stop” as soon as m2 passes through the photogate. Record the times in Data Table A. The times to record are “elapsed time” in the second columns. Ignore the running times in the first columns.

PROCEDURE B

9. The second “elastic” collision you will do is between m3 and m1. In this case, m3 will have a time recorded both before and after the collision. Follow the same procedure as in Procedure 6 and record the times in Data Table B.

PROCEDURE C

10. The third collision you will do is between m1 and m2 again, but this time use the sides with pieces of velcro attached, so that you will have a completely inelastic collision. Follow the same procedure as before, and record the times in Data Table C. Note whether the two gliders traveling together give one time or two, depending on whether the light beam of the photocell is allowed to pass between the two cars stuck together. If you have two times (which should be nearly equal) then you use the length of one (with one of the two recorded times) to calculate v. On the other hand, if there is only one time, then you need to use the length of the two gliders together to calculate v.

PROCEDURE D

11. Now fill in the remainder of the data tables, calculating velocities and momenta. Be careful that at least one of the quantities will be negative, depending on direction of travel. Do calculations in the CGS system of units (for centimeters, grams and seconds) rather than SI (or MKS for meter, kilogram and seconds).

QUESTIONS

1. Based on your experimental results, are we justified in claiming that momentum is conserved when there are no external forces? Explain.
2. For each collision, calculate the percent of kinetic energy lost. Is kinetic energy conserved in any of the collisions? Is there any difference between the “elastic” and the inelastic collision?
3. Are there any everyday interactions, or collisions for which you can think the conservation of momentum would apply? Explain with an example if you say yes, or a reason if you say no.

DATA TABLE A

"ELASTIC COLLISION" (**P**=**p**1+**p**2)

m1 = m2 [m1] ⟶ [m2]

		mass( )	Δt( )	v( )	p( )	**P**( )	%diff
BEFORE COLLISION	m1						
	m2		x				
		length( )	x	x	x	x	
AFTER COLLISION	m1						
	m2						

DATA TABLE B

"ELASTIC COLLISION"

m3 < m1 [m3] ⟶ [m1]

		mass( )	Δt( )	v( )	p( )	**P**( )	%diff
BEFORE COLLISION	m3						
	m1		x				
		length( )	x	x	x	x	
AFTER COLLISION	m3						
	m1						

DATA TABLE C

" COMPLETELY INELASTIC COLLISION"

m1 =m2 [m1] ⟶ [m2]

		mass( )	Δt( )	v( )	p( )	**P**( )	%diff
BEFORE COLLISION	m1						
	m2		x				
		length( )	x	x	x	x	
AFTER COLLISION	m1+m2						