LAB 19. MOMENTUM

Supplies

Collisions: rail, leveling shims, two rail carts with magnetic end Velcro bumpers, one with a spring-release plunger, one auxiliary mass bar

Collisions

What determines the speed and direction of objects after a collision?

Here you will investigate how the velocities of two objects after they collide are influenced by factors such as the type of collision (elastic or inelastic), the velocities of the objects before the collision, and the masses of the objects.

The rail carts contain several features that will help you investigate different factors. At one end they contain repelling magnets. At the opposite end are two pieces of Velcro that will fasten one cart to the other. Finally, one cart contains a spring-loaded plunger that can be used to drive the two carts away from each other. When using the rail carts, be sure that the track is level and that the carts' wheels stay in their grooves on the track. Also check that their wheels roll smoothly, without catching or grinding.

I. One cart stationary, one moving toward it in an elastic collision.

Set up the two carts so that the magnetic bumpers repel upon close approach. Don't collide them so hard that they actually touch.

1. Record the velocities of the two carts before and after the collision. How do they compare to each other? Since you don't know the numerical values, use the symbol "v" and subscripts to distinguish them (v_1, v_2, etc.). Include a sign (+ or –) to indicate direction.

cart	velocity before	velocity after
1		
2		

2. After the collision, where has the momentum of the first cart gone?

3. Is momentum conserved in the collision? Justify your answer.

II. One cart stationary, one moving with two sticking together after collision.

Set up the carts so that the Velcro bumpers will stick together after collision. Don't collide them so hard that they detach.

1. What are the speeds and directions of the two carts before and after the collision? Since you don't know numerical values, use symbols as before.

cart	velocity before	velocity after
1		
2		

III. Both carts in bumper contact with spring release "explosion."

The button on top releases a spring-driven plunger. Set the two carts in contact in the center of the track and release the plunger by tapping it with a pen (fingers tend to add a horizontal force).

1. What is the relative speed of the two carts after the "explosion?" What are their directions?

cart	velocity before	velocity after
1		
2		

2. Write equations for the momenta of each cart after the explosion using the appropriate signs and symbols.

   $p_1 =$

   $p_2 =$

3. Now write an equation for the *net* momentum $\sum p$ of the system after the explosion. What is the numerical value of this net momentum after the explosion?

   $\sum p = p_1 + p_2 =$

4. What was the momentum *before* the explosion? Describe how momentum *is* conserved in this case, even though there was no motion at the beginning but lots of motion after the explosion.

IV. Carts with unequal masses.

Add mass to one of the carts and repeat the above investigations. Describe the velocities of each cart before and after each collision or explosion.

1. Heavy cart stationary, light cart moving toward it in an elastic collision.

cart	before	after
heavy		
light		

2. Light cart stationary, heavy cart moving toward it in an elastic collision.

cart	before	after
light		
heavy		

3. Heavy cart stationary, light cart moving with the two sticking together after collision.

cart	before	after
heavy		
light		

4. Light cart stationary, heavy cart moving with the two sticking together after collision.

cart	before	after
light		
heavy		

5. Spring release explosion.

cart	before	after
heavy		
light		

6. Which of these initial conditions make both carts move in the same direction after the elastic collision?

7. Is momentum conserved when the carts have different masses? Defend your answer.

Questions to consider

- When rail carts collided, how did their rebound trajectories compare when Velcro ends were facing or when magnetic ends were facing?
- Was it possible for one rail cart to be motionless after a "spring-apart" from rest?
- How did the speeds of the rail carts affect the collision outcomes?
- In any collision between two objects, what *one* factor determines which object experiences the greatest velocity change?

Getting Credit

Show this completed worksheet to your instructor for check-off. Answer the questions your instructor asks.