Experiment 5: Conservation of Momentum

EQUIPMENT	
Triple beam balance	Calculator
Two PASCO collision carts	Cart masses
	Bee Spi® photogate
PASCO Cart track	Cart launcher

Momentum

The purpose of this lab is to observe the conservation of momentum for **inelastic** and **elastic** collisions. Momentum is inertia in motion, and can be calculated by multiplying an object's mass by its velocity (i.e., momentum = mass x velocity).

You have also studied something called impulse (impulse = force x time). Impulse is the change in momentum (i.e., force x time = change in momentum). In order to change momentum, an impulse (i.e., a force acting over some time period) must be applied from outside of the system. Impulse can be seen whenever an object is made to speed up or to slow down (i.e., the object's velocity is made to change).

A central law of mechanics is the **conservation of momentum**. This law states, "In the absence of an external force, the momentum a system remains unchanged. In any system wherein all forces are internal-as for example, cars colliding, atomic nuclei undergoing radioactive decay, or stars exploding-the net momentum of the system before and after the event is the same."

In part one of the lab you will explore the conservation of momentum through an **elastic collision** of two carts. In this case the carts will collide, but they will not stick together. For momentum to be conserved the initial momentum (i.e., before collision) of cart *A* plus the initial momentum of cart *B* is equal to the final momentum (i.e., after collision) of cart *a* plus the final momentum of cart *B.* In equation form this relationship looks like:

$$m_{cart\ a} v_{cart\ a\text{-before}} + m_{cart\ b} v_{cart\ b\text{-before}} = m_{cart\ a} v_{cart\ a\text{-after}} + m_{cart\ b} v_{cart\ b-after}$$

If cart B is initially at rest (as is the case in this experiment), then the relationship above becomes

$$m_{cart\ a} v_{cart\ a\text{-before}} = m_{cart\ a} v_{cart\ a\text{-after}} + m_{cart\ b} v_{cart\ b-after}$$

In part two (2) of the lab you will explore the conservation of momentum through an **inelastic collision** of two carts. Inelastic collisions occur when two objects collide and stick together. The initial momentum of one cart plus the initial momentum of the other cart must equal the final momentum of the two cart system once they have collided and stuck together.

$$m_{cart\ a} v_{cart\ a} + m_{cart\ b} v_{cart\ b} = (m_{cart\ a} + m_{cart\ b}) v_{cart\ a+cart\ b}$$

If cart B is initially at rest (i.e., $v_{cart\ b} = 0$), then the relationship above becomes

$$m_{cart\ a} v_{cart\ a} = (m_{cart\ a} + m_{cart\ b}) v_{cart\ a+cart\ b}$$

Procedure

Video of data collection is on YouTube video website below:

https://youtu.be/06M4bsSOnvM Data collection for **elastic** and **inelastic** collisions

https://youtu.be/kklmZONQBwo How to do **part 3** of experiment (elastic collision with added masses)

Equipment setup and determination of mass of cart

1. Measure the mass of 1st cart. Photo of cart mass by triple beam is below. Record this mass in table 1 below.

Figure 1- Mass of cart

2. To ensure that the track is level, place one cart in the middle of the track. If the cart starts to roll one way then you need to adjust the level of the track. This can be done by turning a screw on the leg at one end of the track.

3. Measure starting velocity of 1st cart (see video for data). See figure 2 below for photo of the photogate display. Measure at least five time and record these values in table 1 below.

Figure 2. Photogate (velocity sensor reading 0.61 m/s**)**

Part 1- Elastic Collision

4. Place 2nd cart (B) on track and cock launcher. See figure 3 below. Pull string on launcher to launch cart A into cart B. Both carts have the same mass. Record velocity from velocity sensor.

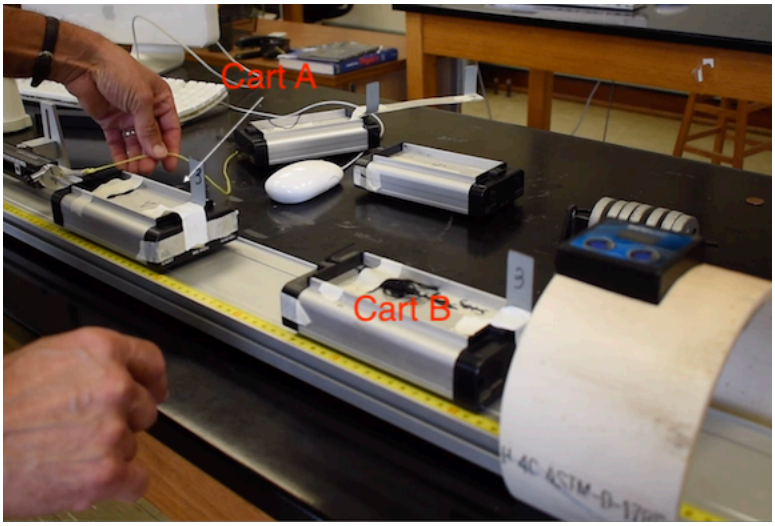

Figure 3. Elastic collision setup

5. Since this is an elastic collision, the **carts will be repelled (by magnets) when placed end to end.)**

6. Place cart A on the track.
7. Make sure the cart launcher is securely fastened to the track. Push the launcher arm back until it locks into place.
8. Set the cart against the launcher making sure that the wheels of the cart are in the grooves on the track.
9. Hit the start button on the velocity sensor. Record the velocity of the 2nd cart B as it goes through the sensor. **The first car will have zero velocity after collision.**
10. Repeat steps 8-10 four (4) more times. Record data in table below.

Part 2- Inelastic Collision

11. Now you will observe an inelastic collision. In this collision both carts will stick together after colliding. Reconfigure (reverse direction of) the bar on Cart A so **the magnets on the carts stick to each other each other when placed end to end.**
12. Please note that you will use same initial velocity as in elastic collision.
13. Now the photogate will measure the velocity of both carts after the collision. Keep in mind that when you make your calculations your initial velocity of cart B will be zero.
14. Reset photogate, and launch your cart. Repeat 4 more times. Record velocity in table 6 below.

Table 1

Cart	Mass of Cart(s) (kg)
A	
B	(same as A)
A+B	

Table 2

Trial	Measured velocity (m/s)
1	
2	
3	
4	
5	

Average velocity of cart A_____m/s

Elastic collision data

Table 3

Before Collision

Cart A **Cart B**

Trial	Velocity Cart A (m/s)	Momentum (kg*m/s)		Velocity Cart B (m/s)	Momentum (kg*m/s)
1				**0**	
2				**0**	
3				**0**	
4				**0**	
5				**0**	

Average initial (before) momentum=_____ kg*m/s

After elastic collision

Table 4

Trial	Velocity Cart A (m/s)	Momentum (Kg*m/s)	Velocity Cart B (m/s)	Momentum (kg*m/s)
1	**0**			
2	**0**			
3	**0**			
4	**0**			
5	**0**			

Average initial (after) momentum=_____ kg*m/s

Inelastic Collision

Table 5 Before Collision

(Use same data as table 3 above)

Cart A **Cart B**

Trial	velocity Cart A (m/s)	momentum kg*m/s		velocity Cart B (m/s)	momentum kg*m/s
1				**0**	
2				**0**	
3				**0**	
4				**0**	
5				**0**	

Average initial (before) momentum =_____kg*m/s

Table 6 After Collision

Carts A+B

Trial	Velocity **Carts A +B** (m/s)	Momentum carts A+B (kg*m/s)
1		
2		
3		
4		
5		

Average final (after) momentum for Carts A +B =_____ kg*m/s

Elastic Collision with increased mass of Cart A

See video on how to do https://youtu.be/kklmZONQBwo

	Cart A (with 500 g added mass)			**Cart B**	
Trial	Velocity Cart A (see video for data) (m/s)	Momentum with added 500g mass (kg*m/s)		Velocity Cart B (m/s)	Momentum (kg*m/s)
1				**0**	
2				**0**	
3				**0**	
4				**0**	
5				**0**	

Explain what you think would happen when the cart A with added 500g mass collides with cart B. Diagrams are helpful. Be qualitative and quantitative (e.g., what is starting and ending momentum) in your description.

Questions

1. Using the results from the experiment, determine whether or not momentum is conserved in each part of the experiment. Is momentum conserved in both (all) parts? Be explicit about whether the final momentum was the same or decreased. If not, give some possible sources of error. *One thing to consider was the final velocity of cart A in elastic collision really zero as was assumed (look at video)?*

2. What is impulse, and where did you see impulse in this experiment?

3. What's the difference between inelastic and elastic collisions? Is momentum conserved in both? If momentum is not conserved in a collision, what can you conclude?

4. When to cars collide in an automobile accident, what type of collision do the cars (typically) experience? Would it be more damaging to the people inside if the cars stuck together or bounced apart? Why?

5. Picture two astronauts holding on to one another in space (Their initial velocity with respect to each other is zero). If one astronaut pushes the other away, what is the total momentum of both astronauts? If one astronaut weighs (on earth) twice as much as the other, what can you say about the velocity of the less massive one compared to the other?