 NAME: KEY

Lab 7-2: **Momentum and Recoil**

Purpose: To determine if momentum is conserved in an "explosion" by measuring the velocities of two carts immediately after a spring is released and they quickly push apart.

Materials: 1 track 1 cart with plunger 1 cart with no plunger
2 500 gram bars 2 motion detectors

Procedure:

1. As always, make sure the track is level on the lab table.
2. Start up Logger Pro and open the file "18 Momentum Energy Coll." The motion detector plugged into "Dig 1" is Position 1 (the red line) and the motion detector plugged into "Dig 2" is Position 2 (the blue line).
3. Call cart A the one with the plunger in it and push in the plunger so that it locks in place.
4. Place both empty carts on the track. Start recording data by clicking on "Collect". Using a meter stick, tap the little knob on the cart to release the spring plunger, pushing the carts apart. Record the velocities for both carts after the spring is released. This is probably easiest to do by using the "Examine" button and just finding the biggest velocities from the velocity vs. time time graphs. Include any negative signs!
5. Place a 500 gram black bar mass in cart B and repeat.
6. Place the second 500 gram black bar oin cart B and repeat.

Data and Results:

mv_i mv_f

	Mass (kg)	Initial Velocity (m/s)	Final Velocity (m/s)	Initial Momentum (kg•m/s)	Final Momentum (kg•m/s)
Cart A	0.5	0			
Cart B	0.5	0			
Totals	---	---	---		

Cart A	0.5	0			
Cart B	1.0	0			
Totals	---	---	---		

Cart A	0.5	0			
Cart B	1.5	0			
Totals	---	---	---		

Conclusions:

1. In terms of Newton's Third Law, why do the two carts go in opposite directions?

   Because the Forces are = and opposite

2. For each trial calculate the momentum of each cart before and after the explosion and record in the table above. Include any negative signs. What is the equation for finding momentum?

   $p = mv$

3. For each trial, calculate the total momentum before and after the explosion by adding up the momentums of each cart. Record your results in the table above.

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4. In all three trials, what was the total momentum of the carts before the explosion? Why does this make sense?

0! Makes total sense! Nothing was moving before the explosion.

5. In all three trials, the total momentum of the carts after the explosion should also have been zero. Did your results show that?

Yes it did (hopefully). Don't worry about a tiny final momentum - if it helps you believe, look at the two final momenta - they are just about ≃ and opposite - the differences are just the little bit of error in doing the experiment!

6. How can the total momentum be zero if both of the carts were moving?

This is tricky - but one cart has a positive momentum while the other cart has a negative momentum - so when you add them up, they CANCEL!

7. When we say that something is conserved in physics, we mean that a quantity does not change during an interaction or over time. In this lab, we are curious about whether momentum was conserved before and after the explosion.
   a. Was the momentum of cart A conserved?

NO

   b. Was the momentum of cart B conserved?

NO

   c. Was the total momentum of cart A plus cart B conserved?

Yes!

8. In the second and third trials, the masses of the carts were not the same.
   a. Which cart experienced a greater change in velocity?

the smaller mass

   b. Which cart experienced a greater force during the explosion?

Forces were the SAME

   c. Which cart experienced a greater change in momentum?

SAME

} Newton's Third Law!

Follow-up Questions:

1. Imagine you do the experiment again, but this time the masses of the carts are 2 kg and 1 kg. If the 1 kg cart has a speed of 1 m/s after the "explosion," how fast is the other cart going?

true for all the following problems!

→ $\Sigma p_i = \Sigma p_f$ Both carts @ rest initially, so $\Sigma p_i = 0$

So $0 = (1)(1) + (2)v \rightarrow 0 = 1 + 2v$ $\boxed{v = -\frac{1}{2}\ m/s}$

BIG IDEA: Total Initial Momentum = Total Final Momentum

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remember "Σ" means total!

2. This time the masses of the carts are 3 kg and 2 kg. If the 2 kg cart has a speed of 1.5 m/s after the "explosion," how fast is the other cart going?

$\Sigma p_i = \Sigma p_f$

$0 = (2)(1.5) + (3)v \rightarrow 0 = 3 + 3v$ $\quad v = -1$ m/s

3. This time the speeds of the carts after the "explosion" are 5 m/s and 2.5 m/s. If the cart going 5 m/s has a mass of 2 kg, what is the mass of the other cart?

$\Sigma p_i = \Sigma p_f$

$0 = (2)(5) + m(-2.5) \rightarrow 0 = 10 - 2.5m$ $\quad m = 4$ kg

4. This time the speeds of the carts after the "explosion" are 4 m/s and 1 m/s. If the cart going 1 m/s has a mass of 2 kg, what is the mass of the other cart?

$\Sigma p_i = \Sigma p_f$

$0 = (2)(1) + m(-4) \rightarrow 0 = 2 - 4m$ $\quad m = \frac{1}{2}$ kg

5. This time the speeds of the carts after the "explosion" are 1.75 m/s and 1.25 m/s. If the cart going 1.75 m/s has a mass of 2 kg, what is the mass of the other cart?

$\Sigma p_i = \Sigma p_f$

$0 = (2)(1.75) + m(-1.25) \rightarrow 0 = 3.5 - (1.25)m$ $\quad m = 2.8$ kg

6. A 1.5 kg gun can fire a 0.005 kg bullet with a speed of 500 m/s. What is the "recoil velocity" of the gun?

$\Sigma p_i = \Sigma p_f$

$0 = (.005)(500) + (1.5)v \rightarrow 0 = 2.5 + 1.5v$ $\quad v = -1.67$ m/s

7. Why would a super-light gun that has a mass of only 0.010 kg, yet could a fire a 0.005 kg bullet with a speed of 500 m/s be really dangerous for the person firing the gun?

It would have a really high recoil velocity!

$0 = (.005)(500) + (0.01)v$

$0 = 2.5 + (.01)v$ $\quad v = -250$ m/s

TO RECAP

The Big Idea in this unit is the Conservation of Momentum. This means the Total Momentum before something happens has to equal the total momentum after something happens. This is written in symbols as

$$\sum p_i = \sum p_f$$

In this lab, the total initial momentum ($\sum p_i$) was always zero because both initial velocities were always zero. The total final momentum was still always zero, because the carts went in opposite directions, the two final momenta are equal and opposite, and so they still add up to zero.