Forces and Momentum in Recoil

Purpose:

The purpose of this experiment is to explore the concepts of impulse and momentum and observe law of conservation of momentum for one-dimensional motion.

Apparatus:

Dynamics cart
Collision cart
Two 500 g masses
Computer with Logger Pro software
Lab-Pro or Lab Quest mini interface
Dynamics track
2 Motion detectors
Connecting cables

Procedure:

1. At each station will be a dynamics track with a motion detector at each end. The motion detectors are plugged into an interface which is connected to a laptop computer. Make sure the track is level by placing a cart on the track. The cart should not roll better in one direction than the other. If the cart tends to roll one way, adjust the track with the leveling screws on either end.
2. Measure the mass of each cart and record. The carts are labeled as cart 1, a dynamics cart, and cart 2, a collision cart.
3. Log onto the computer network and open the Logger Pro program. Open the Physics with Vernier folder, then the Momentum, Energy and Collisions file.
4. Compress the spring of the dynamics cart (cart 1) and place it along with the collision cart (cat 2) together at about the center of the track with the plunger of cart 1 facing cart 2. The Velcro patches should be covered with tape so the carts do not stick together. Cart 1 should be pointed toward motion detector 1 and cart 2 towards motion detector 2. Keep this orientation in all your trials.
    a. What is the physics term for what you did when you compressed the spring of the plunger on cart 1?
    b. Cart 1 now has energy stored in the compressed spring. Where did this energy come from?
5. Before proceeding, make the following predictions and record your answers in your lab journal: (Note: for grading purposes, only the fact that predictions were made will be considered, not whether they are correct or not.)
    a. When the spring release is triggered, it will release the stored energy and produce a force pushing the carts apart. Will the force act on (A) cart 2 only (B) cart 1 only (C) both carts?
    b. Will the force be (A) greater on cart 2 (B) greater on cart 1 (C) equal on both carts?
    c. Predict how the speed of each cart will compare to the other: (A) greater speed for cart 1 (B) greater speed for cart 2 (C) equal speed for each cart
6. Click the *Collect* button on the computer. Using a spoon or other tool provided (not your finger), tap the plunger, releasing the spring so the carts move apart. Be careful you don't move the carts in any way or impede their motion when you tap the spring release. Keep your hands and the spoon out of the way during the motion. Be sure to catch each cart before it rolls off the open end of the track. Click the *Stop* button to stop data collection.
7. Sketch the velocity graph in the data section or in your lab journal. Identify and label the portions of the graph that correspond to:

a. the time when the carts were at rest before the spring was released
b. the time the carts were moving apart
c. the time when the carts were stopped (or too close to the motion detectors to be tracked).

8. Click and drag the mouse to highlight the region where the carts were moving apart at constant speed. Click the STATS button to find the mean (average) velocity for each cart and record in the data table. One of the velocities will be negative. For a moment, disregard this negative sign and check your prediction of the speeds of the carts. Was your prediction correct?
9. Record the velocities in the data table, but be sure you include the negative sign in the data table and all the calculations.
10. For trial 2, add a 500 g mass to the collision cart (cart 2), and repeat the procedure.
11. Make the same predictions and answer the same questions as in trial 1.
12. Record the velocities in the data table.
13. For trial 3, repeat the procedure with two 500 g masses on the collision cart, making predictions, answering questions and recording the velocities of both carts as you did before.

Data Section

Trial 1 graph sketch:

Cart 1 mass _____kg Cart 2 mass _____kg

Calculate the final momentum of both carts in all 3 trials and record in the data table.

Data Table			
	Total Mass (cart + added mass) (kg)	Velocity (after release) (m/s)	Momentum: $p = mv$ (kg m/s)
Trial 1, Cart 1			
Trial 1, Cart 2			
Trial 2, Cart 1			
Trial 2, Cart 2			
Trial 3, Cart 1			
Trial 3, Cart 2			

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Analysis Section

From the Second Law of Motion, we know that $F = ma$ and from the definition of average acceleration we know that $a = \frac{\Delta v}{\Delta t}$. Therefore we can say that: $F = m\frac{\Delta v}{\Delta t}$. Rearranging this equation we see that

$$F\Delta t = m\Delta v$$

Since the time of the interaction had to be the same for each cart, we can see how the forces compare by calculating the right side of the equation above. In physics, the product of the force and the time interval when the force is applied is called the impulse (J) and the product of mass and velocity is called the momentum (p) of the object. From the equation we see that the impulse (on the left side) equals the change in the momentum of the object (on the right side).

Questions:

1. Compare the magnitude of the final momentum for each cart for each trial. What does this show about the forces acting on each object?

   _____

2. Was a larger force exerted on the smaller mass in trials two and three? _____

3. What was the total momentum of the two carts before the spring mechanism was released ($\boldsymbol{p_i}$)? _____

4. According to the Law of Conservation of Momentum, if there are no external forces on the system, then total momentum of the system cannot change. What should the total momentum of the carts be after the release of the spring ($\boldsymbol{p_f}$)? _____

5. Calculate the total final momentum of the two carts ($\boldsymbol{p_f}$) for each trial. Be sure to consider the vector nature of momentum when doing this calculation. (Remember the two carts were moving in opposite directions so one must be negative.)

   a. Trial 1 _____

   b. Trial 2 _____

   c. Trial 3 _____

6. Allowing for a small experimental error, was momentum conserved in this experiment?

   Explain. _____