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CONSERVATION OF LINEAR MOMENTUM II

MEASUREMENTS AND CALCULATIONS

OBJECTIVE

To measure momentum before and after collisions as a way of investigating momentum conservation.

INTRODUCTION

This time we will return to the photogates to measure the velocity of the air-track gliders. Doing so will give us better synchronization than we get with the Motion Probes. Again we use the picket fence to chop the light signal from the gate.

When two objects (such as two air carts) collide elastically, we expect momentum to be conserved. We can express this idea mathematically by setting the momentum before the collision equal to the momentum after the collision:

total momentum before = total momentum after

$$\left(m_1\mathbf{v}_1 + m_2\mathbf{v}_2\right)_{\text{before}} = \left(m_1\mathbf{v}_1 + m_2\mathbf{v}_2\right)_{\text{after}}$$

In this experiment you can test momentum conservation and decide if the collisions are truly elastic.

ACTIVITY 1

1. Weigh the two gliders with the “picket fence” attached. If they have unequal masses, add weights until they are of equal mass. **Record the final glider masses.**
2. Measure the spacing of the bands on the “picket fence.” *Use the bands that are most closely spaced.* **Record this value.**
3. Place both gliders on the air track. Turn on the blower and observe the gliders. Level the track as needed. Then turn off the blower.
4. Once the track is level, place one glider at the center of the track so

that it remains at rest. The other glider should be positioned at one end of the track. On your data sheet, **draw a diagram of the track with the two gliders on it as seen from the side. Label the two gliders. Go back and indicate which mass corresponds to which glider (in the previous question).**

ACTIVITY 2

5. Place the two timing gates over the track. Place them 40 cm from each end of the track. Make sure that the gates are high enough that they will detect the closely spaced bands.
6. **Examine the diagram you made in Step 4 and indicate the locations of the gates on this diagram.** One gate should lie between the two gliders. **Label this gate with the same name as the glider on the end of the track. Label the other gate with the same name as the other glider.**
7. Connect both gates to the photogate port. Connect the port to the USB link. Connect the link to your laptop.
8. Open DataStudio™ by double-clicking on the Conservation.ds icon. The data menu should include two Position icons.
9. Check your Setup values. The icons should say Photogate and Picket Fence. (If not, contact your instructor for assistance). Only the boxes for the positions should be checked. If the band spacings are incorrect, click on the Change Value button and correct the value. *Make sure to enter your value in meters, not centimeters.*

ACTIVITY 3 EQUAL MASSES COLLIDE

10. Turn on the blower. Press Start in DataStudio™ to begin collecting data.
11. Push the glider near the end **gently** towards the stationary glider in the center of the track. The moving glider should pass through its corresponding gate.
12. Allow the struck glider to pass completely through its gate once. Then press Stop before it comes back through the gate again. If the first glider is still moving, allow it to pass back through the gate on its way to the bumper.
13. Observe your results in the position vs. time graph. **Print out your graph to turn in with your data sheets. Label each data run with the appropriate glider number (as in Activity 1).**

14. From the graph, determine the initial velocities of both gliders before impact and the final velocities of both gliders after impact. **Record these values.**
15. Calculate the initial and final momenta of both gliders and **record these values.**
16. Calculate the total momentum before impact and the total momentum after impact and **record your results.**

ACTIVITY 4 HEAVY MASS COLLIDES WITH STATIONARY LIGHT MASS

17. Place 200 grams on the end glider (glider 1). Add no extra weights on the other glider. Move the second glider roughly 50 cm away from the end glider. Move the second gate along with the glider until the two gates are roughly 50 cm apart. The second glider should still lie between the two gates.
18. Turn on the blower and start recording data. Push the end glider **gently** towards the stationary central glider. After the impact, both gliders will still be in motion. Allow both gliders to pass through the second gate, then press Stop.
19. Examine the graph and **explain your observations. Be sure to print out your graph and label each glider's path.**
20. Calculate the initial and final velocities of both gliders and **record.**
21. Calculate the initial and final momenta of both gliders and **record.**
22. Calculate the total momentum before impact and the total momentum after impact and **record your results.**

ACTIVITY 5 LIGHT MASS COLLIDES WITH STATIONARY HEAVY MASS

23. Interchange the two gliders so that the incoming glider will be the light one and the stationary glider will be the heavier one.
24. Turn on the blower and start recording data.
25. Push the end glider **gently** towards the stationary central glider. After the impact, both gliders will still be in motion. Allow both gliders to pass through the gates. Then press Stop.
26. Examine the graph and **explain your observations. Be sure to print out your graph and label each glider's path.**

27. Calculate the initial and final momenta of both gliders and **record these values**.
28. Calculate the total momentum before impact and the total momentum after impact and **record your results**.

ACTIVITY 6

29. Compare the initial and final total momenta for each of the three cases by **computing the percent differences**. The percent difference of two quantities is the absolute value of their difference divided by their average. That is:

$$\text{percent difference} = \frac{|p_{\text{final}} - p_{\text{initial}}|}{\frac{1}{2}(p_{\text{final}} + p_{\text{initial}})} \times 100\%.$$

30. **Explain your results.**

Hand in.

Name _____

CONSERVATION OF LINEAR MOMENTUM

DATA COLLECTION AND CALCULATIONS

ACTIVITY 1 & 2

Record the final glider masses.

Glider	Mass (g)
Glider 1	
Glider 2	

Record the value of the band spacing on the glider flags.

Draw a diagram of the track with the two gliders on it as seen from the side. Label the two gliders. Go back and indicate which mass corresponds to which glider (in the previous question).

Label the gates as directed.

ACTIVITY 3 EQUAL MASSES

Print out your graph to turn in with your data sheets. Label each data run with the appropriate glider.

Record the initial velocities of both gliders.

Record the final velocities of both gliders.

Calculate the initial and final momenta of both gliders and record these values.

Calculate the total momentum before and after impact.

ACTIVITY 4 HEAVY MASS COLLIDES WITH STATIONARY LIGHT MASS

Print out your graph and label each glider's path.

Calculate the initial and final velocities of both gliders and record.

Calculate the initial and final momenta of both gliders and record these values.

Calculate the total momentum before and after impact and record.

ACTIVITY 5 LIGHT MASS COLLIDES WITH STATIONARY HEAVY MASS

Be sure to print out your graph and label each glider's path.

Calculate the initial and final velocities of both gliders and record.

Calculate the initial and final momenta of both gliders.

Calculate the total momentum before and after impact.

ACTIVITY 6

Compute the percent difference for each of the three cases.
Explain your results.