TechLab: Crash and Stick

conservation of momentum in inelastic collisions

PERIOD	1.		
	2.		
GROUP	3.		
	4.		

• Purpose •
In this activity you will verify conservation of momentum in inelastic collisions.

• Initial Apparatus •
___ PASCO Introductory Dynamics System
(dynamics carts, track, and accessories)

• Additional Apparatus for Procedures 4-8 •
___ computer (Phyz MacBook or equivalent)
___ probeware (DataStudio or equivalent)
___ motion sensor (PASport)
___ interface device (USB Link)
___ configuration file created in *TechLab Prep: DataStudious*
___ spreadsheet software (Microsoft Excel or equivalent)
___ "Inelastic Collisions XL" spreadsheet template

• Initial Setup •
1. If you were using the computer in a previous activity, set it aside (put it to sleep and/or let it charge) while you complete Procedures 1–3.

2. Arrange the track so that it is level.

3. Attach the end stop so that the Velcro side faces the track.

• Procedure •
1. THE EVENT
a. Arrange the carts so that they will undergo an **inelastic collision** on the track. When arranged correctly, a **bullet** will move toward a stationary **target**. When the bullet collides with the target, the two stick to each other and move as a single **compound object**.

i. Describe the preparations of the carts and draw a diagram showing how they are aligned before the collision.

ii. Draw a labeled diagram of the apparatus before and after the event. (Use the terms "bullet," "target," and "compound object" appropriately in your diagrams.)
BEFORE   AFTER

iii. Describe the motion of the bullet before the collision and the motion of the compound object after the collision.

b. The initial collision was between two objects with approximately equal mass. Use the mass blocks to arrange collisions of objects with unequal masses. Describe the differences that are apparent when
i. a heavy bullet collides with a light target.

ii. a light bullet collides with a heavy target.

2. CONSERVATION OF MOMENTUM

The bullet has momentum before it collides with the target. The stationary target has none. After the collision, the compound body has momentum.

a. If momentum is conserved, what must be true about the momentum of the bullet before the collision and the momentum of the compound body after the collision?

b. What two quantities must be known to calculate the momentum of the bullet before the collision?

c. What quantities must be known to calculate the momentum of the compound body after the collision?

3. MASS MEASUREMENTS

Record the mass of each item. As with all laboratory work, observe correct use of significant figures.

Plunger Cart	m = _____ kg	Collision Cart	m = _____ kg
Mass Block 500 #1	m = _____ kg	Mass Block 500 #2	m = _____ kg
Mass Block 250 #1	m = _____ kg	Mass Block 250 #2	m = _____ kg

4. SPEED MEASUREMENTS

Arrange the apparatus so that you can measure the speed of a single cart as it moves down the track. For this exercise, measure the cart's speed at two locations on the track.

a. Obtain the apparatus needed for this procedure (listed in the Apparatus section).

$v_1 = ?$ $v_2 = ?$
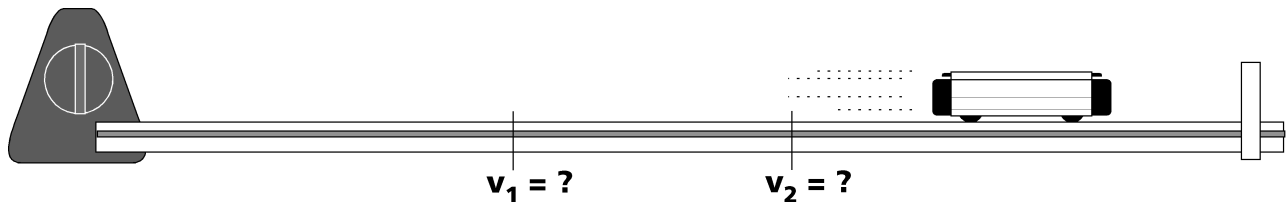
b. Turn the computer on. While the computer is starting...

c. Attach the motion sensor to the track as shown in the diagram above. Make sure the gold disc is aimed horizontally along the track (facing the Velcro end stop).

d. Connect the motion sensor to the interface device. Connect the interface device to the computer.

e. When asked what you would like to do with the sensor, Launch DataStudio.

f. Select Open Activity from the File menu.

g. Locate and open the last file you created in *TechLab Prep: Data Studious.* **It should have a name like 1.05 Track Watcher PG** (where P is your period and G is your group.)

h. Remove ALL data from the activity (from the Experiment menu).

i. Place the cart near the motion sensor.

j. Click the on-screen Start button. Wait until you hear the clicking to go to the next step.

k. Give the cart an abrupt impulse and let it coast toward the Velcro end stop. Let it stick to the end stop.

The configuration file you created in *Data Studious* is designed to start watching the cart when the cart is 30 cm from the motion sensor and stop watching the cart when it is 70 cm from the motion sensor. It generates a graph of velocity vs. position.

Determine the velocity of the cart at position 1 (37.0 cm) and position 2 (63.0 cm) by doing the following.

l. Activate the Smart Tool and drag the Smart Tool crosshairs onto the plot of the motion.

m. Use the arrow keys on the keyboard to move the crosshairs as close as possible to position 1. The ordered pair near the crosshairs are (position, velocity). So the first number should be position 1, the second will be the speed at position 1.

n. i. Record the speed of the cart at position 1:_____

   ii. Record the speed of the cart at position 2:_____

5. MOMENTUM MEASUREMENTS
   a. What was the momentum of the cart at position 1? Show the calculation, starting with the equation. Don't forget correct units for all values, including the answer.

   b. What was the momentum of the cart at position 2? Show the calculation, starting with the equation.

6. INELASTIC COLLISION EVENT ANALYSIS
   a. Delete the previous data run. Arrange the apparatus so that an inelastic collision will happen as follows.
   i. The bullet will move away from the motion sensor toward the stationary target (it will be given an abrupt impulse).
      ii. The bullet will collide with the target when the **back end of the <u>bullet</u>** is 50 cm away from the sensor.
      iii. The compound body will continue until it impacts and sticks to the Velcro endstop.

   b. Activate the motion sensor and run the event.

c. Examine the plot of the event. It should look something like the plots shown in the graphs below. Because friction slows the bullet during its approach and slows the compound body after the collision, we need to find initial and final speeds as close to the collision as possible.
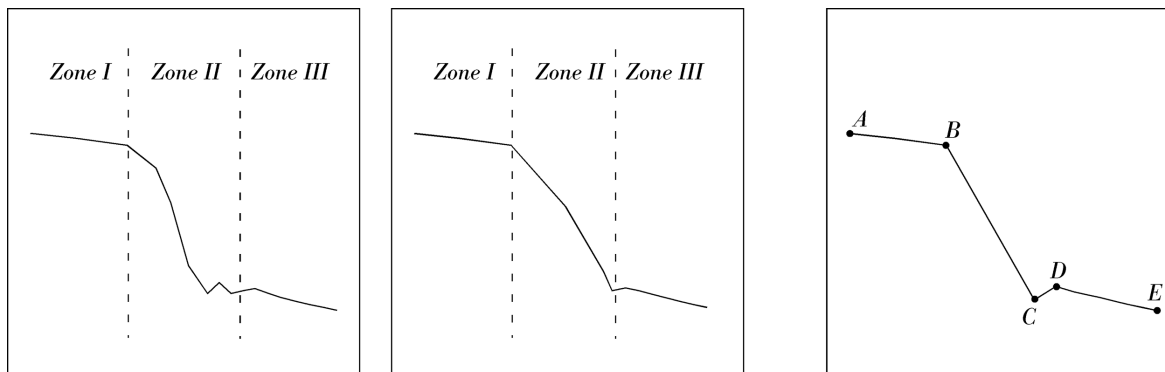
d. Zones. Examine the plots shown above. Make note of the correspondence of the event and the plot.
   i. **Zone I** is before the collision. You will find the initial speed of the bullet here; it's the **last** speed value **before** the drop-off. Notice the bullet is slowing down through the entire zone.

   ii. **Zone II** is during the collision. This is where the collision is in progress. The drop-off is followed by some jerkiness. *Disregard all speed values in zone II.*

   iii. **Zone III** is after the collision. You will find the final speed—the speed of the compound body—here. After the collision, the compound body slows down.

e. Points. Examine the final plot above.
   i. The initial speed of the bullet—its speed just before the collision—is shown at **point B.** As the bullet traveled from point A to point B, it was slowing down. Conservation of momentum is observed when no external forces act. Friction is an external force. Since friction slows the bullet from A to B, we use the speed at B as the initial speed. Disregard the speed at point A.

   ii. The final speed of the compound body is shown at **point D.** Point C is in the "noise" of the collision and is not reliable. Point D shows the fastest speed after the collision. After point D, the compound body slows down due to friction. Disregard the speed at point E.

f. If the event does not produce a good result, delete it and try again. When you think you have recorded a good event, activate the Smart Tool and place it on the plot at the location of the final speed.
   i. Secure a PhyzBlessing.

   ii. Record the initial (bullet) speed _____.

   iii. Record the final (compound body) speed _____.

g. Open the data table. From the dock (task bar), open Excel. From the start-up screen's "New" tab, open the "1.04 Inelastic Collisions XL" template.

h. Re-save this template file, renaming it "Inelastic Data *PG*" using your group's PG code. Save it to the correct folder on the computer. (Keep the file name shorter than 25 characters, please.)

i. Record the bullet mass, target mass, bullet speed, and compound body speed in the first available row ("Trial 1") of the data table. Note: never type anything into the shaded cells. These cells are filled with equations that will act on the data that you enter into the non-shaded cells.

j. Calculate the momentum of the bullet before the collision. Show the calculation below.

k. Calculate the momentum of the compound body after the collision. Show the calculation below.

l. Calculate the percent difference between the momentum of the bullet before the collision (p_1) and the momentum of the compound body after the collision (p'). The percent difference between any two numbers, a and b, is

$$[\, | \, a - b \, | \, / \, (\, a + b \,) \,] \times 200$$

Show the calculation below. The result should be close to what the spreadsheet shows.

m. Calculate the percent difference between the velocity of the bullet before the collision (v_1) and the velocity of the compound body after the collision (v'). Show the calculation below. The result should be close to what the spreadsheet shows.

n. If the trial yielded data that shows conservation of momentum, the spreadsheet will show a comment such as "Good!" or "Beauty! Publish!" on the data table. If the trial yielded data that doesn't show conservation of momentum, a comment such as "Bad" or "Check apparatus" will appear.

7. VARY THE CONFIGURATIONS

a. Return to DataStudio and delete the previous run. Repeat the procedure until you have good data for a light bullet (empty cart) colliding with a heavy target (fully loaded cart). Enter the appropriate data into your Excel spreadsheet. Save the updated spreadsheet (File: Save).

b. Return to DataStudio and delete the previous run. Repeat the procedure until you have good data for a heavy bullet colliding with light target. Enter the appropriate data into your Excel spreadsheet. Save the updated spreadsheet (File: Save).

c. Use the available mass blocks to create two more different mass configurations. Repeat the procedure until you have good data for both of them.

d. When you have five distinct trials, save the updated spreadsheet (File: Save).

e. Produce a print preview showing your spreadsheet in <u>landscape</u> format that <u>fits to one page</u> (you may have to use the setup button and make appropriate adjustments to achieve this).

f. Secure a PhyzBlessing, then print as many copies as there are partners in the group.

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