

Name(s) and Alpha(s)

Date

SP211 Lab 6

Momentum and 1D Collisions

Equipment

The following equipment is necessary to complete this lab in the quantities listed in parenthesis:

LabQuest Mini (1)	Screwdriver (1)
Track (1)	Motion Sensor (1)
Dynamics Cart (1)	Collision Cart (2)
Force Sensor (1)	Clay (small amount)
Black Bar Cart Mass (2)	Force Bracket and Accessories (1)
500 g Mass (1)	

You will also need the Vernier Graphical Analysis software and Google Gemini to complete this lab.

Procedure 1: Force Sensor Calibration

1) Every time you plug a force sensor in or restart Vernier Graphical Analysis, you'll need to calibrate the force sensor. To do this, plug the force sensor into the LabQuest Mini and the LabQuest Mini into your computer.

2) Open Vernier Graphical Analysis and click on the Force button in the bottom right corner of the window, then calibrate. Hang the force sensor on a rod and make sure it is set on ± 10 N. In the "Enter first known value" box, type 0, and click keep.

3) Next hang a 500 g mass from the hook of the force sensor, type 4.9 in the "Enter second known value" box, and click keep.

Experiment 1: Inelastic Collision

1) Attach the force sensor to the force bracket and then attach the force sensor to one end of the track. This should lock it into place so that when something runs into the force sensor it does not move. Now that the force sensor is on its side, zero the force sensor.

2) Find the cup attachment to the force sensor and replace the force sensor's hook with the cup. Shape a small piece of clay into a cone and put it into the cup.

3) Place two mass bars in the bed of the cart and then measure their combined mass using one of the scales in your lab room. Record the combined mass in Table 1 below.

Quantity	Value	Quantity	Value
Mass of Bars & Cart			
$v_{\text{before collision}}$		$p_{\text{before collision}}$	
$v_{\text{after collision}}$		$p_{\text{after collision}}$	

Table 1: Mass and motion sensor data for the inelastic collision.

Work:

4) Place the motion sensor on the opposite end of the track from the force sensor and plug it into the LabQuest Mini. Place the cart in between the motion sensor and the force sensor at least 20 cm from the motion sensor. At this point your set up should look like Figure 1.

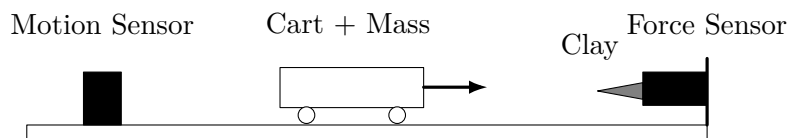


Figure 1: Diagram of Experiment 1's setup. We will use a motion sensor to measure the velocity of the cart as it collides with clay attached to a force sensor.

5) Click on the Mode/Rate button in the bottom left corner of the Vernier Graphical Analysis software and increase the data collection rate to 300 samples/s. While collecting data, give the cart a gentle push so that it collides with the clay. For good results, the collision should take as long as possible; we want several data points to be taken during

the collision. Additionally, the collision should only slightly deform the clay. Upload your motion sensor and force sensor data into Google Gemini.

6) Using your motion sensor data in Google Gemini, determine the average velocity of the cart just before and just after the collision. Record these values in Table 1. Using those results, calculate the momentum of the cart before and after the collision. Show your work!

Question 1: Calculate the impulse of the collision using your momentum calculations from Table 1. Record the equation you used to calculate impulse from momentum and show your work.

Question 2: What is the mathematical relationship between force and momentum? Do the calculus out to show that this is an equivalent form of Newton's Second Law.

Question 3: Integrate your equation from Question 1 to show how impulse and force are related to each other.

Question 4: Calculate the impulse of the collision using your force sensor data and Google Gemini. Why do you trust Google Gemini's result? What is the percent difference between this result and your answer to Question 1?

CHECK POINT:

Experiment 2: Elastic Collision

1) Replace the clay you used in Experiment 1 with a spring. Reset the cart to its original starting position.

Question 5: Considering that the spring will cause the cart to rebound, make a prediction as to whether the magnitude of the impulse will be larger, smaller or the same as in Experiment 1. Explain your reasoning.

2) While collecting data, give the cart a push so that it gently bounces off the spring.

3) Using your motion sensor data in Google Gemini, determine the average velocity of the cart just before and just after the collision. Record these values in Table 2. Using those results, calculate the momentum of the cart before and after the collision. Show your work!

Quantity	Value	Quantity	Value
$v_{\text{before collision}}$		$p_{\text{before collision}}$	
$v_{\text{after collision}}$		$p_{\text{after collision}}$	

Table 2: Motion sensor data for the elastic collision.

Work:

Question 6: Calculate the impulse of the collision using your momentum calculations from Table 2. Record the equation you used and show your work.

Question 7: Calculate the impulse of the collision using your force sensor data and Google Gemini. Why do you trust Google Gemini's result? What is the percent difference between this result and your answer to Question 6?

Question 8: Why is the impulse larger when the cart reverses direction (this experiment) compared to when it just stops (Experiment 1)?

Question 9: Calculate the total kinetic energy of the cart just before and just after the collision. Show your work. Was energy conserved? Why or why not?

CHECK POINT:

5-day section break point _____

Experiment 3: Inelastic Collision Between Two Equal Mass Carts

1) Measure the mass of both of your carts and record them in Table 3 below.

Mass of Cart 1		
Mass of Cart 2		

Table 3: Masses of carts.

2) We are now going to consider a perfectly inelastic collision between two carts. Set up the two carts as shown in Figure 2. Neither cart should have masses in them. The carts

should collide so that their Velcro bumpers face each other because the intent is to cause an inelastic collision.

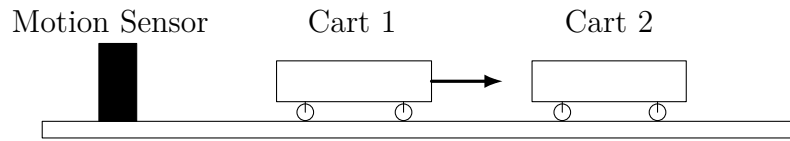


Figure 2: Two equal mass objects

3) Record data of the collision between the two carts with your motion sensor. The carts are more likely to stick together, which we want for an inelastic collision, if cart 1 is given a gentle push to get it moving. Using the motion sensor data and Google Gemini, determine the average velocity of cart 1 before the collision, and the combined average velocity of carts 1 and 2 just after the collision. Record these in Table 4 as v_1 before collision and v_{1+2} after collision.

Quantity	Value	Quantity	Value
v_1 before collision		v_2 before collision	0 m/s
v_{1+2} after collision			

Table 4: Motion sensor data for the inelastic collision between two equal mass carts.

Question 10: What is the system's total momentum before the collision? Show your work!

Question 11: What is the system's total momentum after the collision? Show your work!

Question 12: What is the system's total kinetic energy before the collision? Show your work!

Question 13: What is the system's total kinetic energy after the collision? Show your work!

Question 14: Using your answers to Questions 10 through 13, are kinetic energy and/or momentum conserved?

CHECK POINT:

Experiment 4: Inelastic Collision Between Two Unequal Mass Carts

1) Now we will repeat Experiment 3, but increase the mass of the initially stationary cart (Cart 2) by placing two mass bars on it. Record the carts' new masses in Table 5 below.

Mass of Cart 1	
Mass of Cart 2	

Table 5: Masses of carts.

2) Rerun the experiment and record the new velocities of the carts in Table 6 on the next page.

Quantity	Value	Quantity	Value
v_1 before collision		v_2 before collision	0 m/s
v_{1+2} after collision			

Table 6: Motion sensor data for the inelastic collision between two unequal mass carts.

Question 15: What is the system's total momentum before the collision? Show your work!

Question 16: What is the system's total momentum after the collision? Show your work!

Question 17: What is the system's total kinetic energy before the collision? Show your work!

Question 18: What is the system's total kinetic energy after the collision? Show your work!

Question 19: If you were able to launch cart 1 with the exact same speed as you did in Experiment 3, would you expect the collision to result in a higher or lower final combined velocity? Explain your reasoning.

Question 20: Two ice skaters push apart while standing on frictionless ice. How does this situation illustrate conservation of momentum?

CHECK POINT:

Clean Up

Please return your lab station and the drawer of equipment to a clean and organized form. Follow any directions your instructor gives you about where to return equipment to when you are finished with the lab.