# Pre-Lab Information

Purpose Explore the conservation of linear momentum using a laboratory procedure.

Time Approximately 45 minutes

Question How does changing mass affect colliding objects?

Hypothesis If the total mass of two colliding carts is increased, then the final velocity of the carts decreases, because mass and velocity determine momentum and momentum is conserved during an inelastic collision.

Variables *Independent Variable:* total mass

 *Dependent Variable:* final velocity

Summary In this lab, you will explore how momentum is conserved by generating inelastic collisions between carts. The law of conservation of momentum requires that the total momentum in the system must remain the same, or be conserved, even though mass or velocities of moving objects in a system may change.

In order to explore momentum, you will use a dynamics track and carts with variable masses to observe collisions. The collisions will take place under different conditions. The first type will involve one cart colliding with a stationary cart, and the second will involve the movement of both carts.

Since momentum is given by the relationship

*p*= *mv*

where *p* is the momentum, *m* is mass in kg, and *v* is velocity in m/s, increasing mass will require a decrease in velocity for momentum to remain constant. Likewise, maintaining total momentum while increasing velocity would require a decrease in mass. The law of conservation of momentum requires that mass and velocity have an inverse relationship, in order for momentum before and after a collision to be constant.

Here are the two inelastic collisions you will set up using the track, carts, and motion sensors:

1. Inelastic collision: one cart moving, one cart stationary

2. Inelastic collision: both carts moving

For each type of collision, you will perform three trials in which the mass of the second cart is varied (increased).

# Safety

* Always wear safety goggles when performing an experiment, especially with objects in motion.
* Make sure you understand the proper use and assembly of the cart, track, and sensors.
* Use caution when assembling and adjusting the dynamics track. Dynamics tracks may have sharp edges or other parts that may pinch hands or fingers.
* Behavior in the lab needs to be purposeful.
* Report all accidents—no matter how big or small—to your teacher.

# Lab Procedure

1. **Gather materials.**

|  |  |  |
| --- | --- | --- |
| * 1 dynamics track (1.2 m)
* 2 low-friction dynamics carts, (500 g mass)
* Level
 | * 2 motion sensors
* LoggerPro® software
 | * Two 250 g masses
* Labquest® data collector with USB cord
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1. **Use this diagram as a guide to setup your track.**



* 1. Assemble the dynamics track on a level table. Use a level to check the track, and make sure there is no incline. If necessary, relocate the track to a level, flat surface.
	2. Position motion sensors on either end of the track, pointing toward the middle of the track.
	3. Place the carts near the center of the track. You will adjust the location and mass of the carts as necessary, prior to each run.
	4. Connect the motion sensor and start the data collection software. Follow any equipment and software instructions to start the software for data collection. Your teacher may provide guidelines for you.
	5. Read through the rest of these instructions before proceeding. This will allow you to practice and plan ahead for the trials.
1. **Produce inelastic collisions with one cart moving, one cart stationary (Scenario A).**
	1. For trial 1, the initial mass of each cart is 500 g. Position cart 1 (C1) on the track approximately 0.1 meter from the left end. Position cart 2 (C2) on the track about 0.5 m from the left end. If the track is level, carts should stay in place; if they drift along the track, check the levelness of the track.
	2. Make sure the ends of the carts are positioned so that the attached accessories (such as magnets) will provide an inelastic collision. Check with your teacher for proper cart usage.
	3. Record the mass of C1 and C2 in Table A. Calculate and record the combined mass of the carts as well.
	4. Trigger the start of the LoggerPro® software at the same time you propel the cart. This will record displacement, time, and velocity data.
	5. Push C1 toward C2 with a reasonable speed, about 0.5 m/s. If needed, consult with your lab partners and teacher about proper cart velocities. Be sure to provide a smooth release so you are not changing the velocity of the cart once in motion.
	6. Once the trial is done, stop the software from recording. The software will provide time, displacement, and velocity data to high accuracy. The data will include velocities over time, so choose the velocity for C1 that is immediately prior to the collision. Record the initial velocities for C1 and C2 (zero) in Table A, to two decimal places.
	7. Record the final velocity for the combined mass, C1 + C2. The value should be the velocity most immediate after the collision. Record this velocity, and all velocities in the next trials, to two decimal places.
	8. Repeat Step 3a–g for two more trials. In the second trial, change the mass of C2 to 750 g. In the third trial, adjust the mass of C2 to 1000 g. Be sure to record all masses and velocities in Tables B and C, respectively.
2. **Produce inelastic collisions with both carts moving (Scenario B).**
	1. Adjust cart mass back to 500 g each. Reposition the carts with C1 on the left end of the track, and C2 on the right end, since both carts will have an initial velocity moving toward each other for the collision.
	2. Record the mass of C1 and C2 in Table D. Calculate and record the combined mass of the carts as well.
	3. Trigger the start of the LoggerPro® software at the same time you propel the carts. Push the C1 and C2 carts toward each other with a reasonable speed. Again, be sure to provide a smooth release of each cart.
	4. Once the trial is done, stop the software recording. Choose the velocities for C1 and C2 that are immediately prior to the collision. Record these initial velocities in Table D. Note that one of the initial velocities should be negative, since the carts are traveling in opposite directions.
	5. Record the final velocity for the combined mass, C1 + C2. The value should be the velocity most immediate after the collision. Depending on the outcome, the final velocity could be positive or negative.
	6. Repeat Step 4a–e for two more trials. In the second trial, change the mass of C2 to 750 g. In the third trial, adjust the mass of C2 to 1000 g. Be sure to record all masses and velocities in Tables E and F, respectively.
3. **Calculate and compare values for momentum.**
	1. Calculate the cart momentums in each trial of Scenarios A and B. In each table, find momentum for each cart prior to the collision, and for the combined mass after the collision. Use the formula

*p*= *mv*

where *p* is the momentum, *m* is mass in kg, and *v* is velocity in m/s.

* 1. Compare the total momentum of the carts both before and after the collisions within each trial of Scenarios A and B. Are they the same? Why? If they are different, why would this be? Once you’ve considered results in each trial, compare results between the scenarios. Use the space in Table G to record your observations and explanations; these can be used later in your lab report as part of your analysis.
1. **Compare velocities before and after the collisions.**
	1. Compare the velocities of the carts in all trials, before and after the inelastic collisions. Given that momentum is the product of mass and velocity, how did velocities change? If masses were combined through inelastic collisions, yet momentum was conserved, how would you expect the velocity to change? Record your answers and observations in Table H.
2. **Clean up the lab.**
	1. Put away the track, motion carts, and other equipment in locations specified by your teacher.

# Data

Record your data either in your lab notebook or in the tables below.

**Scenario A: One Cart Moving, One Cart Stationary**

**Table A**

|  |  |  |
| --- | --- | --- |
| **Trial 1** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Table B**

|  |  |  |
| --- | --- | --- |
| **Trial 2** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Table C**

|  |  |  |
| --- | --- | --- |
| **Trial 3** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Scenario B: Both Carts Moving**

**Table D**

|  |  |  |
| --- | --- | --- |
| **Trial 1** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Table E**

|  |  |  |
| --- | --- | --- |
| **Trial 2** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Table F**

|  |  |  |
| --- | --- | --- |
| **Trial 3** | **Before Collision** | **After Collision** |
| **C1** | **C2** | **C1 + C2** |
| ***m*****(kg)** |  |  |  |
| ***v*****(m/s)** |  |  |  |
| ***p*****(kg ∙ m/s)** |  |  |  |

**Table G**

|  |
| --- |
| **Comparison of Momentum before and after the Collisions** |
|  |

**Table H**

|  |
| --- |
| **Comparison of Velocities before and after the Collisions** |
|  |