**Is Momentum Conserved During an Elastic Collision?**

Susan Shaw

011111111

Lab Partners: Alina, Katie

PC 131, Lab 4

Lab Instructor: Terry Sturtevant

Lab IA: Cameron

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**Purpose:** The purpose of this experiment is to see if energy and momentum are conserved during an elastic collision. According to the law of conservation of energy and conservation of momentum, during a collision energy can neither be gained nor lost, but it can be transferred or transformed. During an elastic collision the energy/momentum is transferred from one object to another without being transformed. The goal of this experiment is to create an elastic collision where the energy and momentum prior to the collision can be shown to be the same the after the collision.

**Method:** Refer to Lab Manuel, Chapter 21

**Change in Method:** We did extra trials to make sure we had an elastic collision. After we had put the equipment away, when we looked at the data we realized we had an inelastic collision that we were unable to detect while the collision was occurring. We also perfected out technique as we did trial after trial. We chose to have the light car hit the heavy car so that after the collision both cars would go back through the gate.

**Experimental Results:**

**Instrument Used:**

 0.15 m Ruler Precision Measure is 0.0005 m

 Computer Software Precision Measure is  s

 Acculab Vicon VIC-612 Balance Precision Measure is 0.01 g

**Data:** I decided to use our fourth trial, since with each of the previous trial we were able to learn how to perform the experiment better. For example, we had figured out how hard to push

 the cart for it to be an elastic collision. As well we were trying to be sure that the carts got completely through the timers after the collision occurred. We had also figured out that if we didn’t stop the carts after they cleared the timing area, the cart had a tendency to roll back and cause the timing to continue. I also picked this trial because when the data was transferred to the disk and then to the memory stick some of the data from the trails did not make any sense.

Before the collision, cart 1 was on the right end of the track moving left, and cart 2 was stationary in between the two timing areas. The mass of cart 1 was  kg and the mass of cart 2 was  kg. The precision measure of the computer software used to gather the times was between  s and  s. The distance along the track that was covered between two successive times was  m. The distance travelled during the intervals of time was m, since the distance between two consecutive black marks was m.m. After the collision cart 1 travelled back to the right, and cart 2 travelled to the left.

 **Before Collision:**

|  |  |
| --- | --- |
| Calculations | Results |
|  | 0.1671 s |
|  | 0.1676 s |
|  | 0.1685 s |
|  | 0.1692 s |
|  | 0.1705 s |
|  | 0.1720 s |
|  |  |
| Average  | 0.1691 s |
| Standard Deviation of Time  | 0.0018 s |
| Standard Deviation of the Mean  | 0.0008 s |
| Uncertainty in Time | 0.0008 s |

Table1: Times before Collision

 **After Collision:**

|  |  |  |
| --- | --- | --- |
| Times | Results:Cart 1 | Results:Cart 2 |
|  | 0.30 s | 0.364 s |
|  | 0.33 s | 0.333 s |
|  | 0.37 s | 0.304 s |
|  | 0.41 s | 0.334 s |
|  | 0.53 s | 0.315 s |
|  | 0.62 s | 0.316 s |
|  |  |  |
| Average  | 0.43 s | 0.328 s |
| Standard Deviation of Time | 0.12 s | 0.021 s |
| Standard Deviation of the Mean  | 0.05 s | 0.009 s |
| Uncertainty in Time | 0.05 s | 0.009 s |

Table 2: Time data after collision

**Sample Calculations:**

 

**Calculations for Standard Deviation:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Times |  |  |
|  | 0.30 s | – 0.13 | 0.0169 |
|  | 0.33 s | – 0.1 | 0.01 |
|  | 0.37 s | – 0.06  | 0.0036 |
|  | 0.41 s | – 0.02 | 0.0004 |
|  | 0.53 s |  0.1 | 0.01 |
|  | 0.62 s |  0.19 | 0.0361 |
| Average time | 0.43 s |  |  |
|  |  |  | 0.077 |

Table 3: Beginning the Calculations for Standard Deviation

  

  the standard deviation was 0.12 s and the

 uncertainty in time was 0.05 s.

**Distance:**

 The length of the ladder was m, which was split into 25 segments (13

 black, 12 clear).

 

**Distance Travelled Between successive times.**

 

**Calculations for Velocity and its Uncertainties:**

|  |
| --- |
| **Initial Velocity for Cart 1** |
| Distance is , time is .  |   the velocity is m/s |
|  |
| **Final Velocity for Cart 1** |
| Distance is , time is s.  |   the velocity is m/s |
|  |
| **Final Velocity for Cart 2** |
| Distance is , time is .  |   the velocity is  m/s |

Table 4: Velocity and its Uncertainty

**Calculations for Energy and Momentum:**

**Initial Momentum:**

 The initial velocity of cart 1 was  m/s, and the weight of cart 1 was

  kg. Cart 2 was stationary.



**Uncertainty in Initial Momentum:**



  the initial momentum was 

**Initial Energy:**

 The initial velocity of cart 1 was  m/s, and the weight of cart 1 was

  kg. Cart 2 was stationary.



**Uncertainty in Initial Energy:**



  the initial energy was 

**Final Momentum:**

 The final velocity of cart 1 was  m/s, and the weight of cart 1 was

  kg. The final velocity of cart 2 was  m/s, and the

 weight of cart 2 is  kg.



**Uncertainty in Final Momentum:**



  the final momentum was 

**Final Energy:**

 The final velocity of cart 1 was  m/s, and the weight of cart 1 was

  kg. The final velocity of cart 2 was  m/s, and the

 weight of cart 2 is  kg.



**Uncertainty in Final Energy:**

  the final energy was  j

 **Uncertainty Calculations:**

|  |
| --- |
| Energy: Initial j, Final j |
|  |  |
| Momentum: Initial , Final  |
|  |  |

Table 5: Percent Difference Calculations

**Discussion of Uncertainties**

 There were four possible sources of error for this experiment. The biggest and most important source of systematic error was that our track was slightly sloped. We noticed this when we tried to use the very heavy cart, and the cart would begin to move on its own once it had come to a stop. We used a level to try to level the track, but the level read as if the track was already level. Since all the other tracks were being used by other groups, we had to use this track and make a note that it was not level. To try and correct this as much as we could, we used the light cart and the heavy cart which seemed to be less affected by the slope of the track. Another possible way to try to correct this would be to support the track in more places than just at the ends. It would have helped if we had a shorter level, then we would have been able to tell positively where the track was sloped, and where to add a support to the track to correct the tilt. If the track had been supported in three or four places, it would not be so likely to warp in the middle. The slope of the track was evident by the decrease of the velocity of the cart. When looking at the first time interval, the velocity was 0.38 m/s, and when looking at the last interval, the velocity was 0.34m/s. Part of this slowing down could have also been due to friction.1 Friction, as well as slope could be another source of systematic error. Though the design of the cart and track were meant to minimize friction, neither can ever be totally frictionless when they are in contact with each other. Another possible source of random error could be the computer software that we used for timing. For every trial we did we had the first cart travel through the first gate. After the collision the first cart travelled back through the first gate, and then the second cart would travel through the second gate. When our results were shown on the screen, the data was in the correct spot and the results were very similar for all our trials. When I pulled up our trial results on my computer screen they did not look the same as they did when our results were first shown. For trial one our columns were switched around and we had positive data in all 4 columns despite the fact that our carts had only gone through 3 gates, one gate prior to the collision and 2 gates after the collision. The other possible source of random error was that we had an inelastic collision. An inelastic collision would cause some energy to be wasted in the collision, and since my calculations showed that there was significantly more energy after the collision than before the collision, I do not believe we had an inelastic collision. Our group also did more trials than were called for just in case we had an inelastic collision once we started to analyze the data. While we collected the data we tried to ensure that we didn’t have an inelastic collision by being careful with how hard we pushed the cart. We also listened to make sure that we didn’t hear the carts collide. As well we watched the collision to make sure we didn’t see the carts touch.

**Conclusion:**

 I have concluded that both momentum and energy were not conserved during our one dimensional elastic collision. The momentum prior to the collision was . The momentum after the collision was . The percentage difference between the momentum prior to and after the collision was 35.83%. The energy prior to the collision was j, and the energy after the collision was j. The percentage difference between the energy prior to and after the collision was 32.4%. Both the momentum and the energy decreased after the collision. The reason that both the energy and momentum decreased was that the carts, especially the first cart, were just able to clear the spot where the timing took place. When we tried to push the carts just a little bit harder, we ended up with an inelastic collision. The first cart had its velocity go from –0.279 m/s to –0.0687 m/s between the first interval and the last interval. The second cart also slowed between the first and last intervals but to a much lesser degree, by approximately 0.03m/s.2,3

**References:**

 Fundamentals of Physics 8th edition by Jearl Walker

 Wikipedia