Worksheet for Lab 5: Conservation

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Use this sheet to enter and submit your answers to the questions asked in the gray boxes on the Lab Instructions document. When you have completed this worksheet, save this file as a .pdf and upload the pdf to the canvas assignment associated with this lab. If you have any trouble converting to a pdf, please ask you Lab Instructor or Lab Assistant.

Remember to use complete sentences and that these text boxes will increase in size as you add more content.

Propagation of Uncertainty

Show your work for the propagation of uncertainty for each value. Use the word equation editor or paste a picture of your work here.

Based on the data that you took today, write and answer the questions in the following sections. Remember that even though you will have the same data as your partner, the writing in these sections should be done individually.

Experimental Method

One of the first steps we took was zeroing the ultrasonic sensors with the carts at a position that can be reset for each trail. Another important step we took was reversing one of the sensors and realigning both the sensors, in order to accurately measure the collision, resulting in a positive value. In addition, we made sure the cart was at least 15 centimeters away from the sensor, so the sensor would be able to trace the motion of the cart. We then conducted both the collisions multiple times to make sure we got consistent, accurate data. Every time we took measurements of the collisions, we made sure the carts started in the same position for every trial. We scaled the graphs and recorded the relevant data to accurately analyze the collisions. Lastly, we calculated the correct uncertainty for the data.

Results

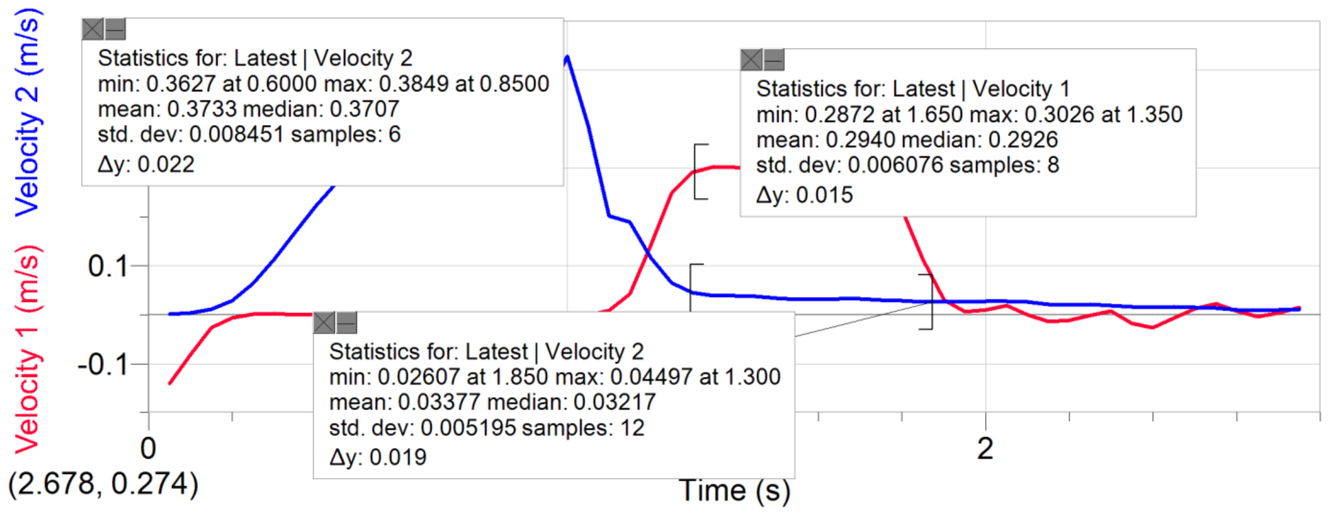

Figure 1: Velocity vs time graphs of the elastic collision between cart a and cart b

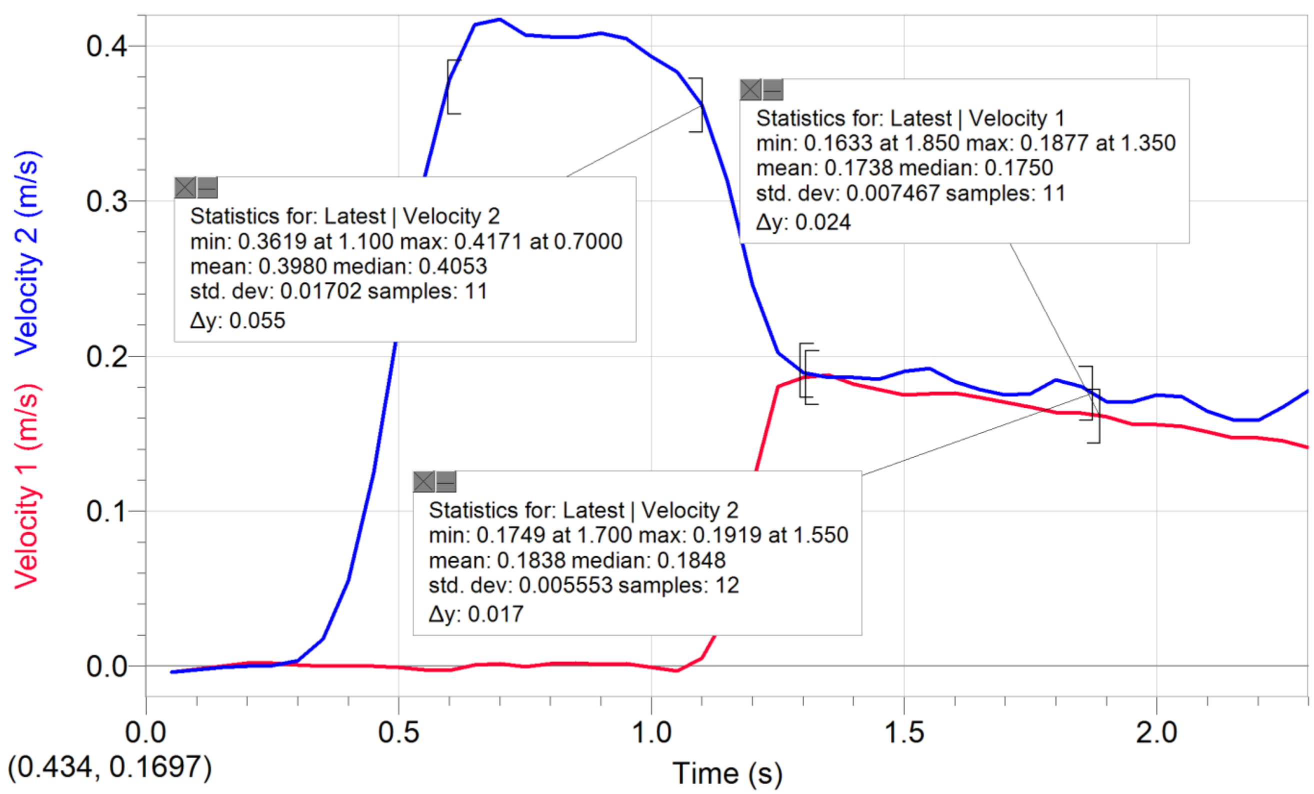

Figure 2: Velocity vs time graphs of the inelastic collision between cart a and cart b

```
In [19]: import statistics as stat
## Inelastic collision
m1 = .4995
m2 = .499
m1uncert = .00025
m2uncert = .0045
v1i = .398
v1f = .174
v2f = .184
v1iuncert = .004
v1funcert = .002
v2funcert = .002

KEi=(1/2)*(m1)*v1i*v1i
KEf=(1/2)*(((m2)*v2f*v2f)+((m1)*v1f*v1f))

KEiuncert = ((m1uncert/m1) + (v1iuncert/v1i)) * (1/2)*m1*v1i* v1i
#KEfuncert = (m2uncert/m2) + (m1uncert/m1) + (v1funcert/v1f) + (v2funcert/v2f)

KEfuncert = (((m1uncert/m1) + (v1funcert/v1f)) * (1/2)*m1*v1f* v1f) + (((m2uncert/m2) + (v2funcert/v2f))

pi = m1*v1i
pf = m1*v1f + m2*v2f

piuncert = (m1uncert/m1) + (v1iuncert/v1i)
pfuncert = (m1uncert/m1) + (m2uncert/m2)

print("KE initial =", KEi)
print("KE initial uncertainty =", KEiuncert)
print("KE final =", KEf)
print("KE final uncertainty =", KEfuncert)

print("P initial =", pi)
print("P initial uncertainty =", piuncert)
print("P final =", pf)
print("P final uncertainty =", pfuncert)
```

```
KE initial = 0.039561399000000004
KE initial uncertainty = 0.0004174025000000001
KE final = 0.016008503
KE final uncertainty = 0.0002586895
P initial = 0.198801
P initial uncertainty = 0.010550751756781909
P final = 0.17872899999999997
P final uncertainty = 0.009518536572644787
```

```
In [ ]:
```

```
import statistics as stat
## Elastic collision
m1 = .499
m2 = .4995
m1uncert = .0045
m2uncert = .00025
v1i = .373
v1f = .294
v2f = .034
v1iuncert = .0015
v1funcert = .002
v2funcert = .002

KEi=(1/2)*(m1)*v1i*v1i
KEf=(1/2)*(((m2)*v2f*v2f)+((m1)*v1f*v1f))

KEiuncert = ((m1uncert/m1) + (v1iuncert/v1i)) * (1/2)*m1*v1i* v1i
KEfuncert =  (((m1uncert/m1) + (v1funcert/v1f)) * (1/2)*m1*v1f* v1f) + (((m2uncert/m2) + (v2funcert/v2f)

pi = m1*v1i
pf = m1*v1f + m2*v2f

piuncert = (m1uncert/m1) + (v1iuncert/v1i)
pfuncert = (m1uncert/m1) + (m2uncert/m2)

print("KE initial =", KEi)
print("KE final =", KEf)
print("KE final uncertainty =", KEfuncert)
print("KE initial uncertainty =", KEiuncert)
print("P initial =", pi)
print("P initial uncertainty =", piuncert)
print("P final =", pf)
print("P final uncertainty =", pfuncert)
```

```
KE initial = 0.0347126855
KE final = 0.021854493
KE final uncertainty = 0.00035831449999999994
KE initial uncertainty = 0.0004526354999999999
P initial = 0.186127
P initial uncertainty = 0.013039483793323911
P final = 0.163689
P final uncertainty = 0.009518536572644787
```

Mass of cart a	Mass of cart b	Velocity of cart a before elastic collision	Velocity of cart b before elastic collision	Velocity of cart a after elastic collision	Velocity of cart b after elastic collision	Momentum before elastic collision	Momentum after elastic collision	Kinetic energy before elastic collision	Kinetic energy after elastic collision
.499 kg ± .0045kg	.4995 kg ± .00025	.294 m/s ± .002	0 m/s	.373 m/s ± .0015	.034 m/s ± .002	.186 kg·m/s ± .0013	.164 kg·m/s ± .00095	.0219J ± .00035	. 0345J ± .00045

Mass of cart a	Mass of cart b	Velocity of cart a before inelastic collision	Velocity of cart b before inelastic collision	Velocity of cart a after inelastic collision	Velocity of cart b after inelastic collision	Momentum before inelastic collision	Momentum after inelastic collision	Kinetic energy before inelastic collision	Kinetic energy after inelastic collision
.499 kg ± .0045	.4995 kg ± .00025	0 m/s	.398 m/s ± .004	.174 m/s ± .002	.184 m/s ± .002	.199 kg·m/s ± .01	.179 kg·m/s ± .009	.0396 J ± .00025	.016 J ± .00041

The velocity of cart a in the inelastic collision is .294 m/s which is greater than the velocity of cart b before the inelastic collision, which is zero m/s, because cart a collides into car b. The velocity of cart a after the inelastic collision is .398 m/s which is greater than the velocity of cart b after the inelastic collision which is .373 m/s, because cart a collides with cart b with a greater initial velocity and pushes off cart b with a greater final velocity. The velocity of cart a in the elastic collision is 0 m/s which is less than the velocity of cart b before the elastic collision, which is .398 m/s, because cart b collides into cart a. The velocity of cart a after the inelastic collision is .174 m/s which is greater than the velocity of cart b after the inelastic collision which is .184 m/s. These values are very close, as both the carts are stuck together and therefore have velocities that are close to the same value. The initial kinetic energy before the elastic collision is .0219 J which differs from the final kinetic energy after the elastic collision which is .0345 J. Even taking into consideration the uncertainty, the initial and final kinetic energies differ. The difference in kinetic energies is .0126 J ± .0001. The initial kinetic energy before the inelastic collision is .0396 J which differs from the final kinetic energy after the elastic collision which is .016 J. The difference in kinetic energies is .0236J ± .00016. The initial and final kinetic energies for the inelastic collision differ, as it is not in the range of the uncertainty. The momentum before the elastic collision was .186 kg·m/s which is close to the momentum after the elastic collision that is .164 kg·m/s. The difference in momentums was .022 kg·m/s ± .00035. The momentum before the inelastic collision was .199 kg·m/s which is close to the momentum after the elastic collision that is .179 kg·m/s, considering the uncertainty.

Conclusion

Elastic collision for kinetic energy the discrepancy between the values is negligible. With the value being close to zero, we can say that the energy in the collision is conserved. The same holds true for the momentum. Because the propagated error is infinitesimal, the initial and final momentum can be considered equivalent. Our data suggests that the momentum is conserved in both the elastic and inelastic collisions. The kinetic energy in the inelastic collision was also conserved, as the values were relatively similar. The initial and final kinetic energies of the inelastic collision were not similar, so the energy was not conserved when both carts collided. Sources of error may have arisen from the placement of the cart on the tacks or the placement of the sensor. Another source of error may have occurred from the human error of manually pushing the cart. In addition, energy is lost in the collision, as can be seen be heard from the sound of the two carts colliding.

Graph and Data Checklist You should have 2 graphs with the appropriate title labels and a complete caption, answered all of the questions highlighted by the gray boxes and written an experimental methods, results, and conclusions section.