Conservation of Momentum

Name:

PES 1150 Prelab Questions

Lab Station: 003

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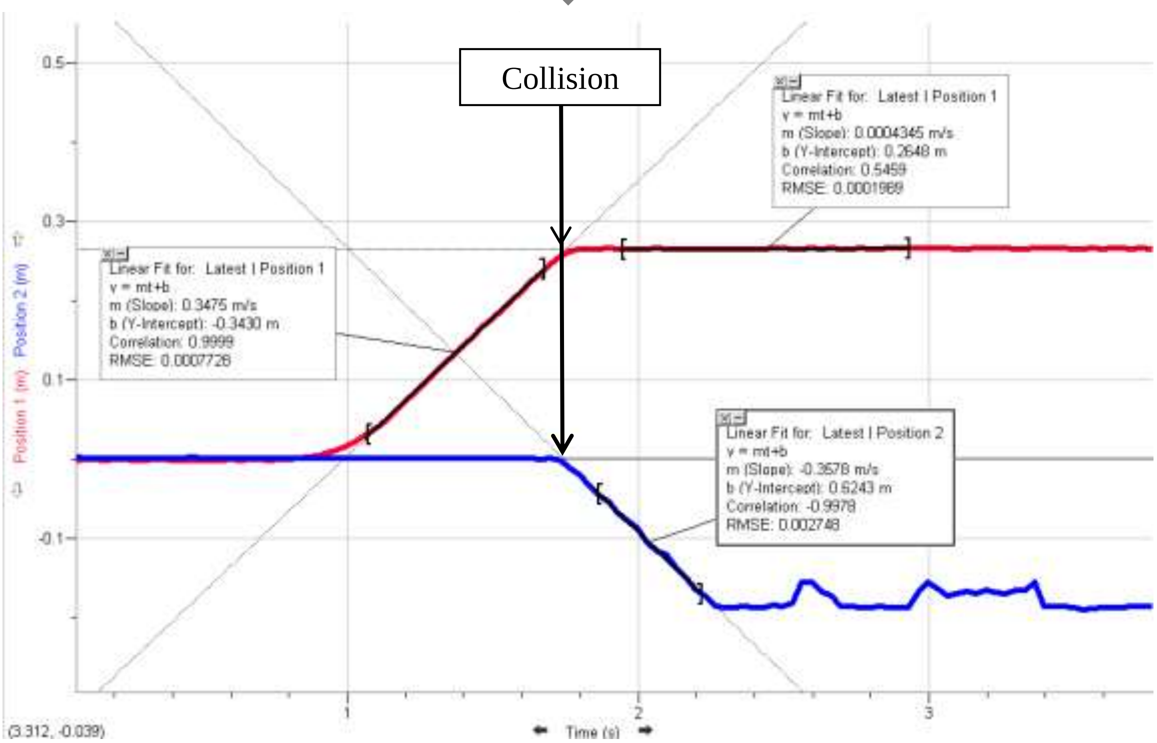
Elastic Collision

Consider a head-on collision between two carts. One is initially at rest and the other moves toward it. The carts bounce off each other in an elastic collision.



Fill out the tables below and determine weather or not momentum is conserved.

Mass of cart 1	0.510 kg		Mass of cart 2	0.498 kg

Velocity of cart 1 before collision (m/s)	Velocity of cart 2 before collision (m/s)	Velocity of cart 1 after collision (m/s)	Velocity of cart 2 after collision (m/s)
0.3475	0	0.000434	0.3578

Momentum of cart 1 before collision (kg•m/s)	Momentum of cart 2 before collision (kg•m/s)	Momentum of cart 1 after collision (kg•m/s)	Momentum of cart 2 after collision (kg•m/s)	Total momentum before collision (kg•m/s)	Total momentum after collision (kg•m/s)	Ratio of total momentum after/before
0.177225	0	0.0002215	0.1781844	0.177225	0.1784059	1.0067

Show your work here

Determining the velocity of Cart 1 before the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 1 (red line) before the collision:

$$position\ 1 = \left(0.3475\frac{m}{s}\right)t + (-0.3430\,m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(0.3475\frac{m}{s}\right)t + (-0.3430\,m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]
0.3475	-0.3430

Determining the velocity of Cart 1 after the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 1 (red line) after the collision:

$$position\ 1 = \left(0.0004345\frac{m}{s}\right)t + (0.2648\,m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(0.0004345\frac{m}{s}\right)t + (0.2648\,m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]
0.0004345	0.2648

Determining the velocity of Cart 2 after the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 2 (blue line) after the collision:

$$position\ 2 = \left(-0.3578\frac{m}{s}\right)t + (0.6243\,m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(-0.3578\frac{m}{s}\right)t + (0.6243\,m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]

0.3578	0.6243

** [NOTE: By examining the setup of the system (see comments above), we can see that the second sensor will record a negative velocity toward the sensor for cart 2. We then must change its sign to compensate for the direction the cart is actually moving. Recall that a velocity is *both* a magnitude and direction – so both must be carefully considered when analyzing momentum problems.] **

Determining the momentum of Cart 1 before the collision:

We know that momentum is given by:

$$p = mv$$

Using the velocity we found from above, we can plug everything right into the equation for momentum.

$$p_{1,before} = (0.510\ kg)\left(0.3475\frac{m}{s}\right) = 0.177225\ N\,s$$

$$\boxed{p_{1,before} = 0.177225\ \frac{kg\ m}{s}}$$

Determining the momentum of Cart 1 after the collision:

$$p_{1,after} = (0.510\ kg)\left(0.0004345\frac{m}{s}\right) = 0.000221595\ N\,s$$

$$\boxed{p_{1,after} = 0.000221595\ \frac{kg\ m}{s}}$$

Determining the momentum of Cart 2 after the collision:

$$p_{2,after} = (0.498\ kg)\left(0.3578\frac{m}{s}\right) = 0.1781844\ N\,s$$

$$\boxed{p_{2,after} = 0.1781844\ \frac{kg\ m}{s}}$$

Determining the total momentum before the collision:

$$p_{Total,before} = \sum_{i=1}^{n} p_{i,before} = p_{1,before} + p_{2,before}$$

$$p_{Total,before} = \left(0.177225 \frac{kg\,m}{s}\right) + \left(0 \frac{kg\,m}{s}\right)$$

$$\boxed{p_{Total,before} = 0.177225 \ \frac{kg\ m}{s}}$$

Determining the total momentum after the collision:

$$p_{Total,after} = \sum_{i=1}^{n} p_{i,after} = p_{1,after} + p_{2,after}$$

$$p_{Total,after} = \left(0.000221595 \frac{kg\,m}{s}\right) + \left(0.1781844 \frac{kg\,m}{s}\right)$$

$$\boxed{p_{Total,after} = 0.178405995 \ \frac{kg\ m}{s}}$$

Determining the ratio of total momentums (After/Before):

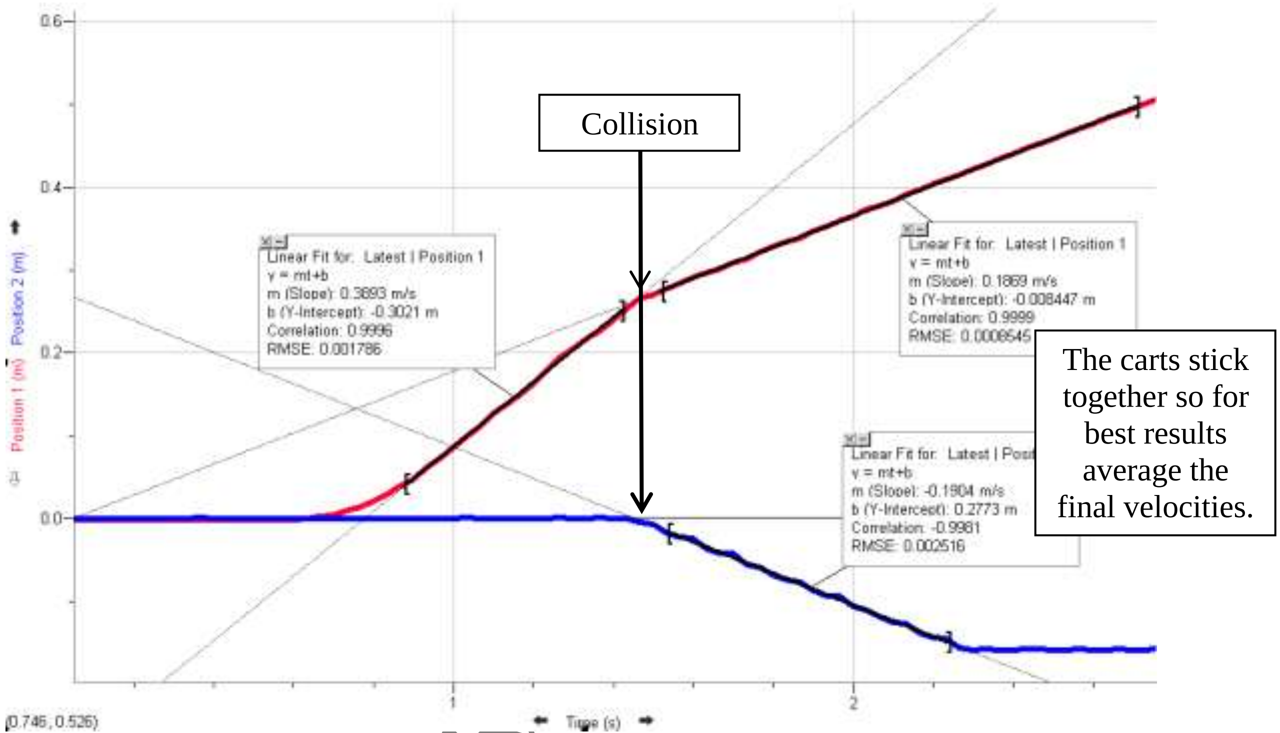
$$Ratio\ \ of\ \ total\ \ momentums = \frac{p_{Total,after}}{p_{Total,before}}$$

$$\boxed{Ratio\ \ of\ \ total\ \ momentums = \frac{0.178405995 \ \frac{kg\,m}{s}}{0.177225 \frac{kg\,m}{s}} = 1.0067}$$

Since the ratio of the total momentum is nearly exactly 1, this means momentum is conserved, and the theory holds true.

Inelastic Collision

Consider a head-on collision between two carts. One is initially at rest and the other moves toward it. The carts stick to each other in an inelastic collision.



Fill out the tables below and determine weather or not momentum is conserved.

Mass of cart 1	0.510 kg

Mass of cart 2	0.498 kg

Velocity of cart 1 before collision (m/s)	Velocity of cart 2 before collision (m/s)	Velocity of cart 1 after collision (m/s)	Velocity of cart 2 after collision (m/s)
0.3893	0	0.18865	0.18865

Momentum of cart 1 before collision (kg·m/s)	Momentum of cart 2 before collision (kg·m/s)	Momentum of cart 1 after collision (kg·m/s)	Momentum of cart 2 after collision (kg·m/s)	Total momentum before collision (kg·m/s)	Total momentum after collision (kg·m/s)	Ratio of total momentum after/before
0.198543	0	0.0962115	0.0939477	0.198543	0.1901592	0.95777

Show your work here

Determining the velocity of Cart 1 before the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 1 (red line) before the collision:

$$position\ 1 = \left(0.3893\frac{m}{s}\right)t + (-0.3021m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(0.3893\frac{m}{s}\right)t + (-0.3021m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]
0.3893	-0.3021

Determining the velocity of Cart 1 after the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 1 (red line) after the collision:

$$position\ 1 = \left(0.1869\frac{m}{s}\right)t + (-0.003447\,m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(0.1869\frac{m}{s}\right)t + (-0.003447\,m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]
0.1869	-0.003447

Determining the velocity of Cart 2 after the collision:

Using the best fit lines from Logger Pro, we are given the following equation for Cart 2 (blue line) after the collision:

$$position\ 2 = \left(-0.1904\frac{m}{s}\right)t + (0.2773\,m)$$

If we compare the equation for kinematic 2D motion for the x-position with the found trendline, we can easily see by evaluation that the following constants correlate directly:

$$x = v_{o,x}t + x_o$$

$$x = \left(-0.1904\frac{m}{s}\right)t + (0.2773\,m)$$

Thus:

$v_{o,x}$ [m/s]	x_o [m]
0.1904	0.2773

** [NOTE: By examining the setup of the system (see comments above), we can see that the second sensor will record a negative velocity toward the sensor for cart 2. We then must change its sign to compensate for the direction the cart is actually moving. Recall that a velocity is *both* a magnitude and direction – so both must be carefully considered when analyzing momentum problems.] **

Determining the average velocity of the two carts after the collision:

$$\langle v \rangle = \frac{v_1 + v_2}{2} = \frac{0.1869\frac{m}{s} + 0.1904\frac{m}{s}}{2} = 0.18865\frac{m}{s}$$

Determining the momentum of Cart 1 before the collision:

We know that momentum is given by:

$$p = mv$$

Using the velocity we found from above, we can plug everything right into the equation for momentum.

$$p_{1,before} = (0.510\ kg)\left(0.3893\frac{m}{s}\right) = 0.198543\ N\,s$$

$$\boxed{p_{1,before} = 0.198543\ \frac{kg\ m}{s}}$$

Determining the momentum of Cart 1 after the collision:

$$p_{1,after} = (0.510\ kg)\left(0.18865\frac{m}{s}\right) = 0.0962115\ N\,s$$

$$\boxed{p_{1,after} = 0.0962115\ \frac{kg\ m}{s}}$$

Determining the momentum of Cart 2 after the collision:

$$p_{2,after} = (0.498\ kg)\left(0.18865\frac{m}{s}\right) = 0.0939477\ N\,s$$

$$\boxed{p_{2,after} = 0.0939477\ \frac{kg\ m}{s}}$$

Determining the total momentum before the collision:

$$p_{Total,before} = \sum_{i=1}^{n} p_{i,before} = p_{1,before} + p_{2,before}$$

$$p_{Total,before} = \left(0.198543\frac{kg\,m}{s}\right) + \left(0\frac{kg\,m}{s}\right)$$

$$\boxed{p_{Total,before} = 0.198543\ \frac{kg\ m}{s}}$$

Determining the total momentum after the collision:

$$p_{Total,after} = \sum_{i=1}^{n} p_{i,after} = p_{1,after} + p_{2,after}$$

$$p_{Total,after} = \left(0.0962115 \frac{kg\,m}{s}\right) + \left(0.0939477 \frac{kg\,m}{s}\right)$$

$$\boxed{p_{Total,after} = 0.1901592 \frac{kg\ m}{s}}$$

Determining the ratio of total momentums (After/Before):

$$Ratio\ \ of\ \ total\ \ momentums = \frac{p_{Total,after}}{p_{Total,before}}$$

$$\boxed{Ratio\ \ of\ \ total\ \ momentums = \frac{0.1901592 \frac{kg\,m}{s}}{0.198543 \frac{kg\,m}{s}} = 0.95777}$$

Since the ratio of the total momentum is nearly exactly 1, this means momentum is conserved, and the theory holds true.