Law of Conservation of Momentum

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Purpose

The purpose of this lab report is to apply the knowledge and skills that is learned in class to use and apply it in an experiment that demonstrates events that might happen in your daily life.

Background Information

What are the differences between speed, velocity and acceleration? Speed is how fast an object is moving. It is the total distance covered per unit of time. Thereby, speed has only magnitude. On the other hand, velocity has both magnitude and direction, and is a vector quantity. Lastly, acceleration is the change in velocity over time. An object is considered to be accelerated when its speed, direction, or both changes.

Some of Newton's law have very important role in this experiment, therefore, will we briefly discuss about it. Newton's first law of motion (known as the Law of Inertia) states that every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it. Newton's second law of motion states that the rate of change of momentum is directly proportional to the impress motive force and takes place in the direction in which the force acts. Lastly, Newton's third law of motion states that whenever one object exerts a force on a second object, the second object exerts are equal and opposite force on the first.

In this lab, we will focus on Law of Conservation of Momentum which is derived from Newton's third law of motion. Beginning with its definition, momentum is the product of mass and velocity, and is a property of moving things. It is a quantity that describes an object resisting to stop and can be described as "inertia in motion". If an object is in motion or is moving, then it has momentum. Momentum is directly proportional to both object's mass and velocity. This basically means that if the mass and velocity of an object increase, its momentum will also increase.

Equation:

$$p = mv$$

The Law of Conservation of Momentum states that when objects collide in an isolated system, thus momentum is conserved. The sum of the momentum of the two objects before collision is equal to the sum of the momentum of the two objects after collision. It means that the final momentum of a system is equal to the initial momentum. Therefore, the amount of momentum gained by one object is equal to the amount of momentum lost by the other object. This shows that momentum cannot be lost in a collision, instead it is transferred from one object to the other object. Conservation of Momentum can described by the following equation

$$m_1 v_{1_i} + m_2 v_{2_i} = m_1 v_{1_f} + m_2 v_{2_f}$$

Materials

Carts

Mass

Motion Detector

Stopwatch

Track

Labquest

Procedure

Manually calculate the velocity of carts.

Calculate the velocity of a cart that moving on a straight line without putting any mass onto it.

- Put the cart at the end of the track (where the motion detector is located)
- Measure the distance starting from the point where the cart is placed to the end of the track
- Push the cart
- Record the time using the stopwatch
- Calculate the velocity of the cart, using the formula distance over time
- Repeat the same process with another cart
- Calculate the average velocity

Using the Labquest to determine the velocity of the reaction, place Cart B in the middle of the track (at rest), and set Cart A in motion by pushing it. This will result in Cart A colliding to Cart B and joining together until they stop.

Experiment with no mass on the cart

- Place one cart at the end of the track and another cart at the middle.
- Press the start button
- Push the cart that is being placed at the end of the track (where the motion detector is)
- Collect the data and graph, this will be automatically recorded by the LabQuest, and will be shown as a plotted graph
- Send the result to your email
- Analyze the result using the graph

Experiment with mass on cart A and on cart B

- Place the mass on Cart A which being placed at the end of the track (where the motion detector is) and place Cart B at the middle without any mass on it.
- Press the start button
- Push Cart A
- Collect the data and graph, this will be automatically recorded by the LabQuest, and will be shown as a plotted graph
- Sent the result to your email
- Analyze the result from the graph
- Repeat the same process, but put the mass on Cart B instead of Cart A

Data and Analysis

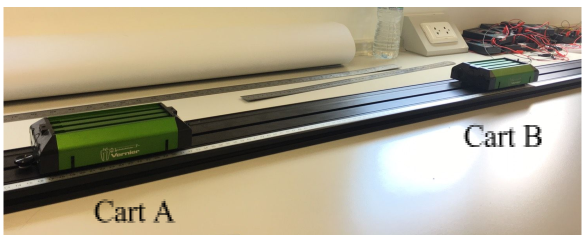
We pushed Cart A and Cart B individually to calculate its velocity.

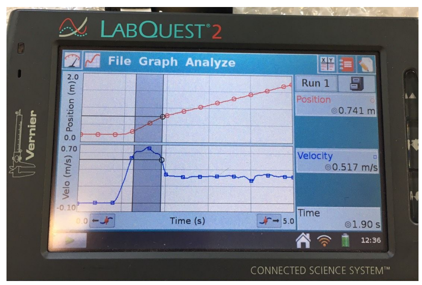
$Distance = 198\text{m} \quad t_A = 5.15\ s \quad t_B = 5.60\ s$

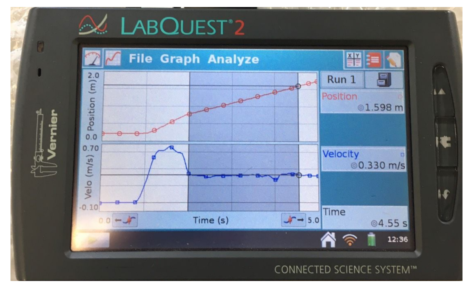
$$velocity = \frac{distance}{time}$$

$$v_A = \frac{198}{5.15} = 38.45\ m/s$$

$$v_B = \frac{198}{5.60} = 35.36\ m/s$$



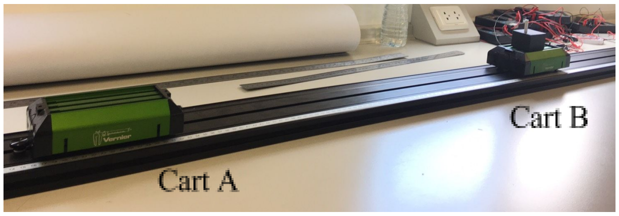


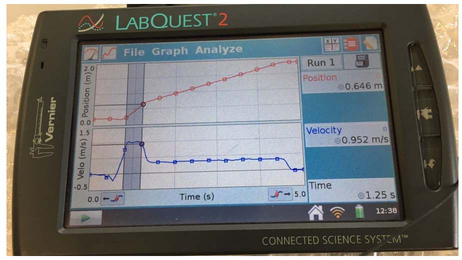


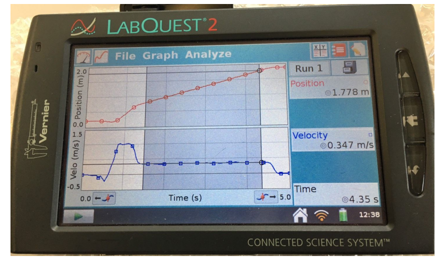
Both Cart A and B has no mass on it. We inserted a force onto Cart A, it then pushes Cart B and both of them move towards the end. By this we can calculate its velocity

$v_1 = 0.517\ m/s \quad t_1 = 1.90\ s \quad v_2 = 0.330\ m/s \quad t_2 = 4.55\ s$

$$\overline{v} = \frac{v_1+v_2}{2} = \frac{0.517+0.330}{2} = 0.4235\ m/s$$



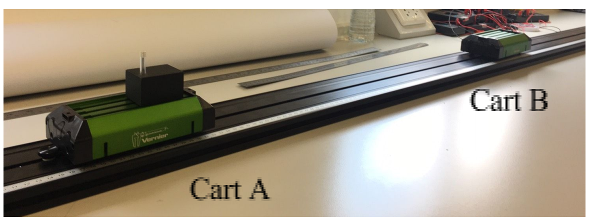


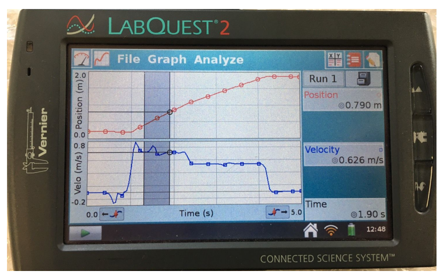


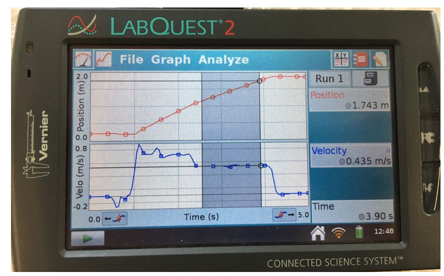
We added mass to Cart B. We inserted a force onto Cart A, it then pushes Cart B and both of them move towards the end. By this we can calculate its velocity

$v_1 = 0.952\ m/s \quad t_1 = 1.25\ s \quad v_2 = 0.347\ m/s \quad t_2 = 4.35\ s$

$$\overline{v} = \frac{v_1+v_2}{2} = \frac{0.952+0.347}{2} = 0.6495\ m/s$$







We added mass to Cart A. We inserted a force onto Cart A, it then pushes Cart B and both of them move towards the end. By this we can calculate its velocity

$v_1 = 0.626\ m/s \quad t_1 = 1.90\ s \quad v_2 = 0.435\ m/s \quad t_2 = 3.90\ s$

$$\overline{v} = \frac{v_1+v_2}{2} = \frac{0.626+0.435}{2} = 0.5305\ m/s$$

From the data, we can observe that the initial velocity is less than the final velocity. This is because the initial velocity is the part where the cart does not move yet, while the final velocity is when the cart moves.

Furthermore, from this experiment, we can conclude that the momentum before is equal to the momentum after. From the formula $m_1 v_{1_i} + m_2 v_{2_i} = m_1 v_{1_f} + m_2 v_{2_f}$ we can prove:

From Newton's Third Law,

$$F_A = -F_B$$

We can determine that,

$$F = ma$$

$$F = m \frac{\Delta v}{\Delta t}$$

$$F = \frac{\Delta p}{\Delta t}$$

$$\frac{\Delta p_A}{\Delta t} = -\frac{\Delta p_B}{\Delta t}$$

Therefore, we do not consider the time,

$$\Delta p_A = -\Delta p_B$$

$$\Delta p = p_2 - p_1$$

$$\Delta p = mv - mu$$

$$\Delta p = m(v - u)$$

$$\Delta p = m(\Delta v)$$

$$\overline{v} = (v - u)$$

$$\Delta p = m(v - u)$$

$$\Delta p_A = m_A (v_A - u_A) \qquad \Delta p_B = m_B (v_B - u_B)$$

$$m_A v_A - m_A u_A = -m_B v_B + m_B u_B$$

$$m_A v + m_B v_B = m_A u_A + m_B u_B$$

$$momentum\ before = momentum\ after$$

Conclusion

To conclude, this experiment help us to apply our knowledge of Newton's Third Law of Motion and Conservation of Momentum into real situations in our life. From this, we can adapt our knowledge to use in our daily life situations. Moreover, we also calculated the velocity of the carts being pushed and observe the effects that is displayed. We learned that the momentum of the cart being pushed are the same from the beginning till the end.

Appendices