LAB 2 Laboratory Activity — Velocity and Momentum

As you know, you can increase the speed of a shopping cart by pushing harder on its handles. You can also increase its speed by pushing on the handles for a longer time. Both ways will increase the momentum of the cart. How is the momentum of an object related to the time that a force acts on it? In this experiment, you will investigate that question.

Strategy

You will observe the effect of a net force on a cart.
You will measure the velocity of the cart at various times.
You will determine the momentum of the cart.
You will relate the momentum of the cart and the time during which the force acted on it.

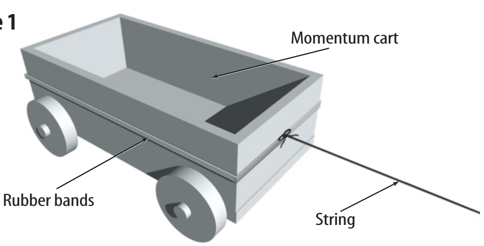
Materials

utility clamp
ring stand
2 plastic-coated wire ties (1 short, 1 long)
pulley
metric balance
momentum cart
2–3 rubber bands
1-m length of string
100-g mass
3–4 books
plastic foam sheet
meterstick
masking tape
stopwatch/timer
felt-tip marker

Procedure

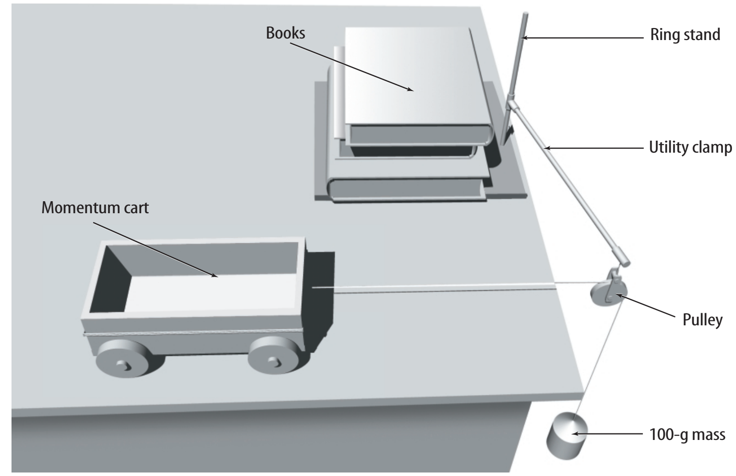
1. Attach the utility clamp to the ring stand. Using the short plastic-coated wire tie, attach the pulley to the clamp.
2. Use the metric balance to find the mass of the cart. Record this value in the Data and Observations section on the line provided.
3. Wrap the rubber bands around the cart lengthwise.
4. Tie one end of the string around the rubber bands as shown in Figure 1. Tie a loop at the opposite end of the string. Pass the string over the pulley.
5. Wrap the long plastic-coated wire tie securely around the 100-g mass. Attach the mass to the loop on the string with the wire tie.
6. Place the ring stand near the edge of the table. Adjust the position of the pulley so that the string is parallel to the table top as shown in Figure 2. Be sure that the 100-g mass can fall freely to the floor. Place several heavy books on the base of the ring stand.
7. Place a plastic foam sheet beneath the mass.

Figure 1



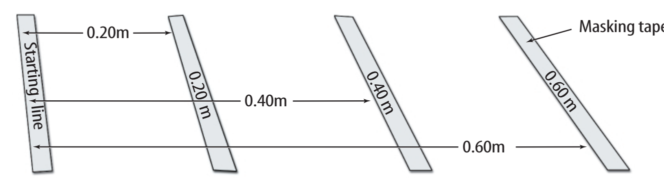
Laboratory Activity 2 (continued)

Figure 2



8. Pull the cart back until the 100-g mass is about 80 cm above the foam sheet. Have your lab partner place a strip of masking tape on the table marking the position of the front wheels. Release the cart. Observe the motion of the cart. Record your observations on a separate sheet of paper. **CAUTION:** *Have your partner stop the cart before it runs into the pulley.*
9. Using the marker, label the strip of masking tape *Starting Line.* Use the meterstick to measure a distance of 0.20 m from the starting line. Place a strip of masking tape on the table to mark this distance. Be sure to have the strip of masking tape parallel to the starting line. Label the strip of masking tape *0.20 m.* Measure and label distances of 0.40 m and 0.60 m in the same manner. See Figure 3.
10. Pull the cart back with one hand until its front wheels are on the starting line. Hold the stopwatch in the other hand. Release the cart and immediately start the stopwatch. Measure the time for the front wheels to cross the 0.20-m line. **CAUTION:** *Have your partner stop the cart before it reaches the pulley.* Record the distance and time values as Trial 1 in Table 1.

Figure 3



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Laboratory Activity 2 (continued)

11. Repeat step 10 twice. Record the values as Trials 2 and 3.
12. Repeat steps 10 and 11 to measure the time for the front wheels to cross the 0.40-m and 0.60-m lines.

Data and Observations

Table 1

	Time (s)		
Distance (m)	Trial 1	Trial 2	Trial 3

Table 2

Distance (m)	Average time (s)	Average velocity (m/s)	Final velocity (m/s)	Momentum (g·m/s)

Graph 1

Laboratory Activity 2 (continued)

1. Calculate the average times for the cart to travel 0.20 m, 0.40 m, and 0.60 m. Record these values in Table 2.
2. Calculate the average velocity for each distance by dividing distance traveled by average time. Record these values in Table 2.
3. Because the cart started from rest and had a constant force acting on it, the velocity of the cart at a given distance from the starting line is equal to twice its average velocity for that distance. That is, the velocity of the cart as it crossed the 0.20-m line is twice the value of the average velocity that you calculated for 0.20 m. Calculate the velocity of the cart as it crossed the 0.20-m line, the 0.40-m line, and the 0.60-m line. Record these values in Table 2.
4. Calculate the momentum of the cart as it crossed the 0.20-m, 0.40-m, and 0.60-m lines by multiplying the mass of the cart by its velocity. Record these values in Table 2.
5. Use Graph 1 to make a graph of your data. Plot the average time on the *x*-axis and the momentum on the *y*-axis. Label the *x*-axis *Time (s)* and the *y*-axis *Momentum* (P).

Step 1. Mass of cart: ______ g

Step 8. Observation of motion of a cart:

___

___

Questions and Conclusions

1. What force caused the cart to accelerate?

___

2. Why was it necessary to have a constant force acting on the cart?

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___

3. What is the value of the momentum of the cart before you released it?

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4. What does your graph indicate about how momentum is related to the time that a constant force acts on an object?

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5. Why does a shot-putter rotate through a circle before releasing the shot?

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Strategy Check

______ Can you measure the velocity and determine the momentum of a cart?

______ Can you explain the relationship between the momentum of a cart and the time during which the force acted on it?