6A Newton's First and Second Laws

What is the relationship between force and motion?

NAME ____________________

PER. ____

The relationships between force and motion are known as Newton's laws. These are among the most widely used relationships in all of physics. The first law explains what happens when there is NO net force on an object, and the second law explains what happens when there IS a net force. The two laws are closely related. We will focus in this investigation on what happens to the Energy Car's motion when you change the force and the mass separately. Both laws apply!

Materials

- Energy Car
- Data Collector and photogate
- 3 same-size rubber bands
- 3 steel marbles
- Digital balance (or triple-beam balance)

1 Making predictions

Newton's second law explains what happens to the acceleration of an object when you change the force applied or change the mass of the object. For this first part of the investigation you will use different amounts of force to launch the car. You will not measure the resulting acceleration, because you would have to measure it while the car is still being acted upon by the rubber band, and this is impossible. Instead, you will measure the RESULT of the acceleration caused by the force of the rubber band. The RESULT will be measured by looking at changes in the car's speed as it rolls along the track after the launch.

a. Make a prediction: What will happen to the speed of the car as the force gets larger?

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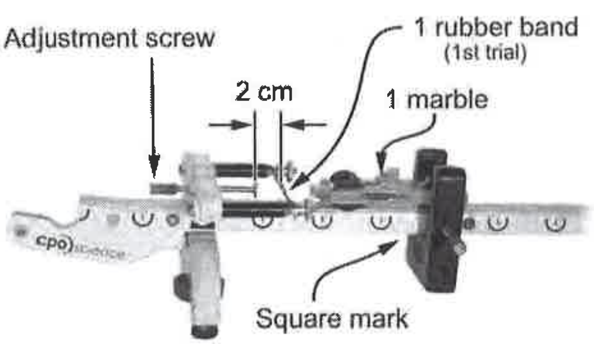
2 Changing force with constant mass



Rest your palm on the wood and pull the car against the screw with your finger on the tab nearest the far end of the car.

1. Set up the long straight track with a rubber band on one end and a clay ball on the other end. Adjust the screw so the rubber band deflects about two centimeters. Be sure to stretch the rubber band once or twice before using.
2. Put one photogate on the first square mark after the rubber band.

3. Put one marble in the center of the car. Use the screw to launch the car using the same deflection of the rubber band each time. This means the same force is applied to each launch. Try to get three launches with times that are within 0.0015 seconds. Average these times and record the result in Table 1.
4. Repeat the experiment with two and three rubber bands. Stretch before using!
5. Calculate the car's speed. Remember to use the tab width, 1.00 cm, for the distance.

Table 1: Changing force data

Number of rubber bands	Time through photogate (s)	Speed (cm/s)

3 Stop and think

a. During which portion of the car's motion is the rubber band affecting its speed?

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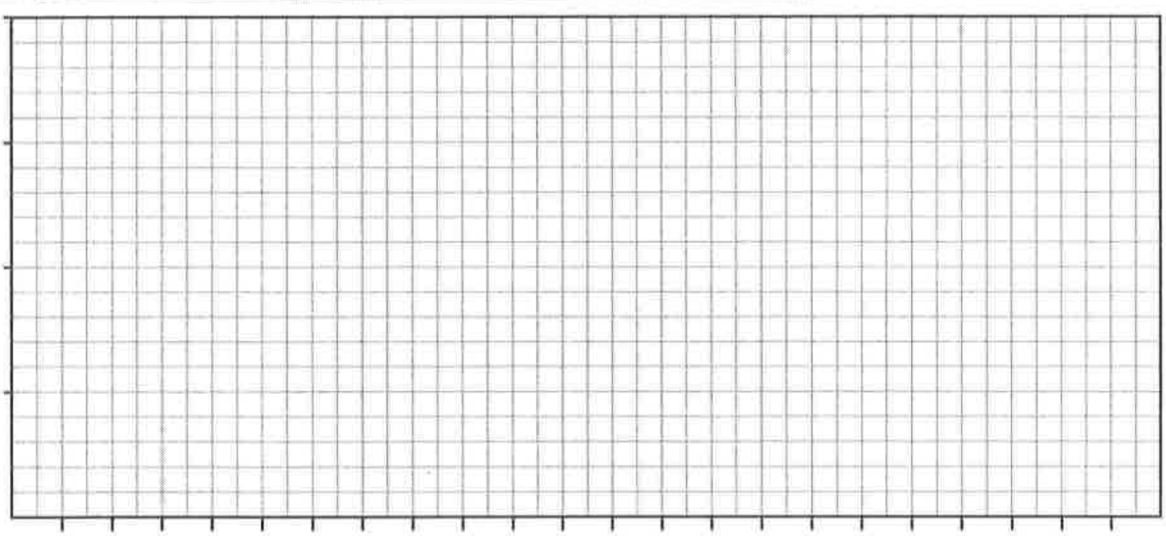
b. Make a graph showing the speed of the car on the y-axis and the number of rubber bands on the x-axis. As the force was increased, what happened to the speed of the car?

Title: ______________________________

y-axis: ______________________________



x-axis: ______________________________

c. Why was the same mass used for all trials (with different force)?

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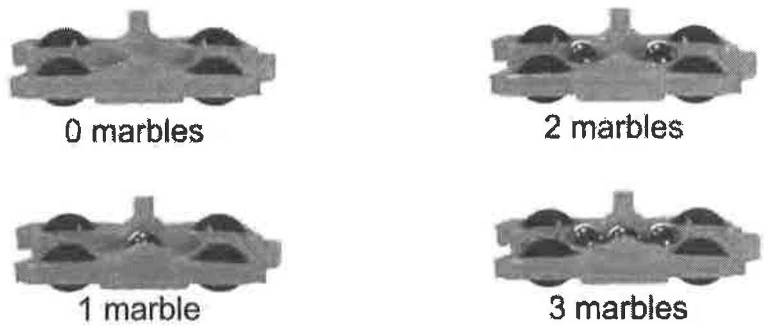
4 Changing mass with constant force

Use 1 rubber band to launch cars with 0, 1, 2, and 3 marbles.



1. Put a single rubber band on the launching end of the track. Stretch it before using. Leave the photogate in the same place as it was (on the first square mark after the rubber band).
2. With the screw in the same place, launch cars of four different masses. Record the times in Table 2.
3. Measure the mass of the car with 0, 1, 2, and 3 steel marbles.
4. Calculate the car's speed. Remember to use the tab width, 1.00 cm, for the distance.

Table 2: Changing mass data

Mass of car (g)	Time through photogate (s)	Speed (cm/s)

5 Applying what you have learned

a. Use Table 2 to graph the speed of the car (y) against the mass (x). Does your graph show a direct relationship or an inverse relationship?

Title: ______________________

y-axis: ______________________

x-axis: ______________________

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b. Why did the speed change when the same launching force from the rubber band was applied to cars of different mass? How do your observations support your answer?

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c. Newton's First Law is often called "The Law of Inertia". How does this law apply to the car's motion when you changed the mass but kept the force constant?

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d. Do you think the force applied to an object causes speed itself or causes changes in speed? Support your answer with at least one sentence of explanation for why you believe your answer is correct.

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When an object's speed changes we say the object *accelerates*. Acceleration occurs whenever speed changes. To be precise, acceleration means the "change in speed divided by the change in time".

$$\text{Acceleration} = \frac{\text{change in speed}}{\text{change in time}}$$

e. Based on your experimental results, propose a mathematical relationship between the variables F (force), a (acceleration), and m (mass).

6 Fun challenge

Try this additional mini-experiment to see something interesting. You will launch the car with one rubber band and no marbles. Then you will launch the car with TWO rubber bands and TWO marbles in the car. This means you will double both the force and the mass at the same time. How will the times compare? Make a prediction.

1. Launch the car with one rubber band. Stretch the rubber band before using. There should be no marbles in the car. Get three times that are within 0.0015 s of each other and average. Record the time average in Table 3.
2. Launch the car with two rubber bands (be sure to stretch first!) and 2 marbles (placed in front and back of car). Get three times that are within 0.0015 s of each other and average. Record the time average in Table 3.

Table 3: Doubling Force and Mass

	Time through photogate (s)
1 rubber band, no marbles	
2 rubber bands, 2 marbles	

a. What do you notice about the times?

b. Explain your result. How does it compare to your prediction?