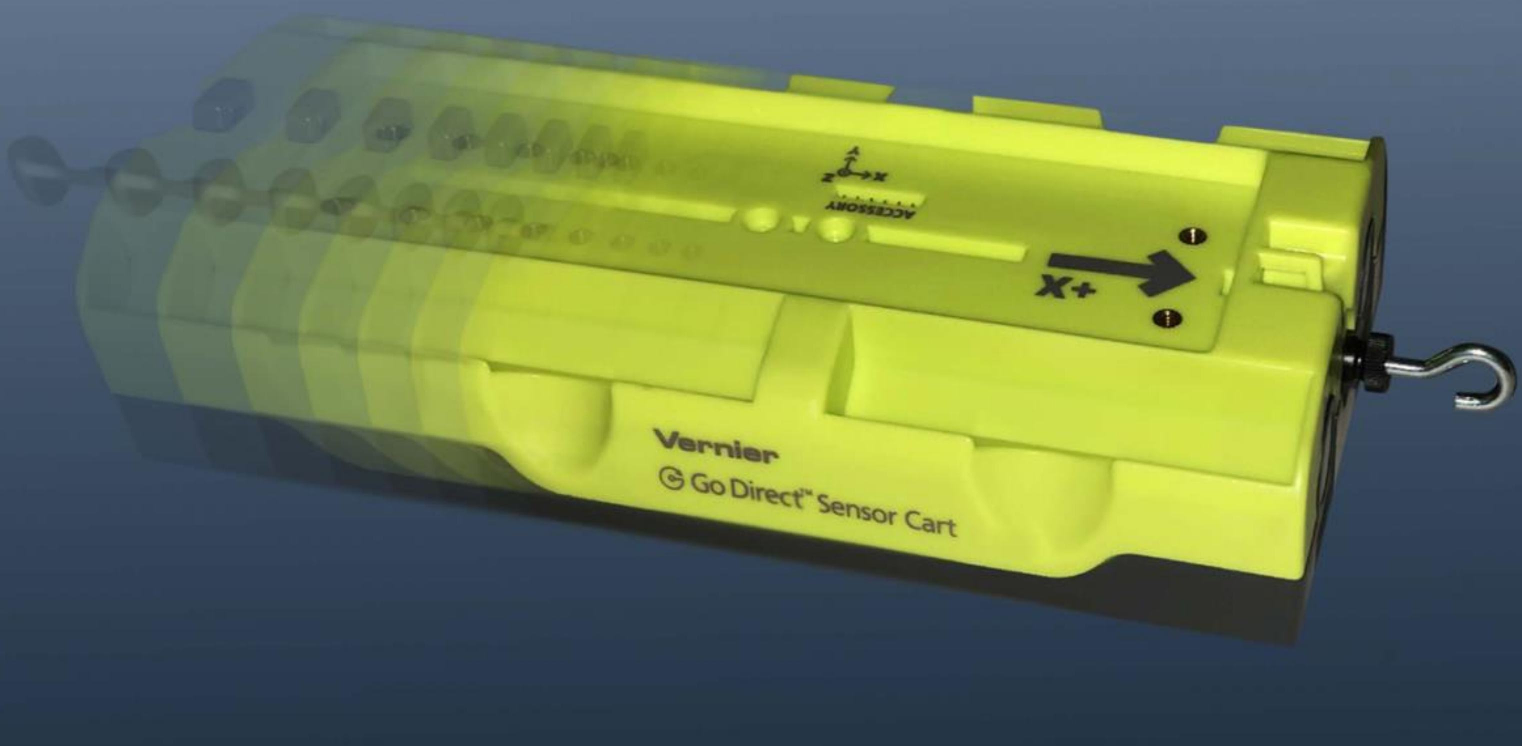
SENSOR CART PHYSICS



Roger F. Larson

STEM SOLUTIONS

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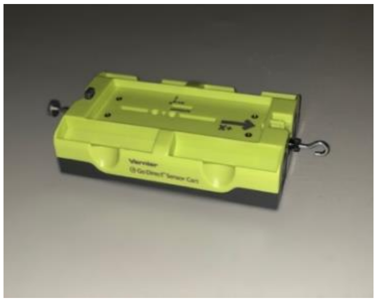
Sensor Cart Physics



	Required Materials								Vernier Accessories					
	Sensor Cart, GDX-CART-G/Y	Smooth level table or ramp (1 m)	C-clamp	Book (used as end stop)	Hooked mases	Digital scale	500 mL beaker, water, golf ball	Wood block	Dynamics Track System, DTS-GDX	End stop, DTS-GDX	Friction Pad DTS-PAD	Hoop springs, GDX-CART-AK	Hook-and-pile tabs, GDX-CART-AK	Cart masses (4), GDX-CART-AK
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INVESTIGATION 9

Hooke's Law: *Stretching Rubber Bands*

INTRODUCTION

It would be rare to find a home or office that didn't have a few rubber bands hiding in a drawer or cabinet. We find all sorts of uses for these stretchy loops. Large elastic bands 5 cm wide and 30 cm long and larger are now popular and used by physical therapists for strength training exercises. A 20-pound barbell always exerts a force of 20 pounds whether you hold it at shoulder level or above your head. On the other hand, does an elastic band always exert the same force as it is stretched from? Robert Hooke, a contemporary of Isaac Newton is given credit for first exploring this question. The relationship describing the force and stretch distance of elastic materials is known as Hooke's Law.

The Sensor Cart is the perfect tool to measure the force applied and the resulting change of position while stretching a rubber band. Your task is to use the Sensor Cart and a rubber band to determine the relationship between forces applied and the resulting amount of stretch of a rubber band.

Before collecting data view the event video below and then sketch a graph of force vs. position that describes the stretching of a rubber band. Place your graph in the Predicted Outcome section of your lab report.

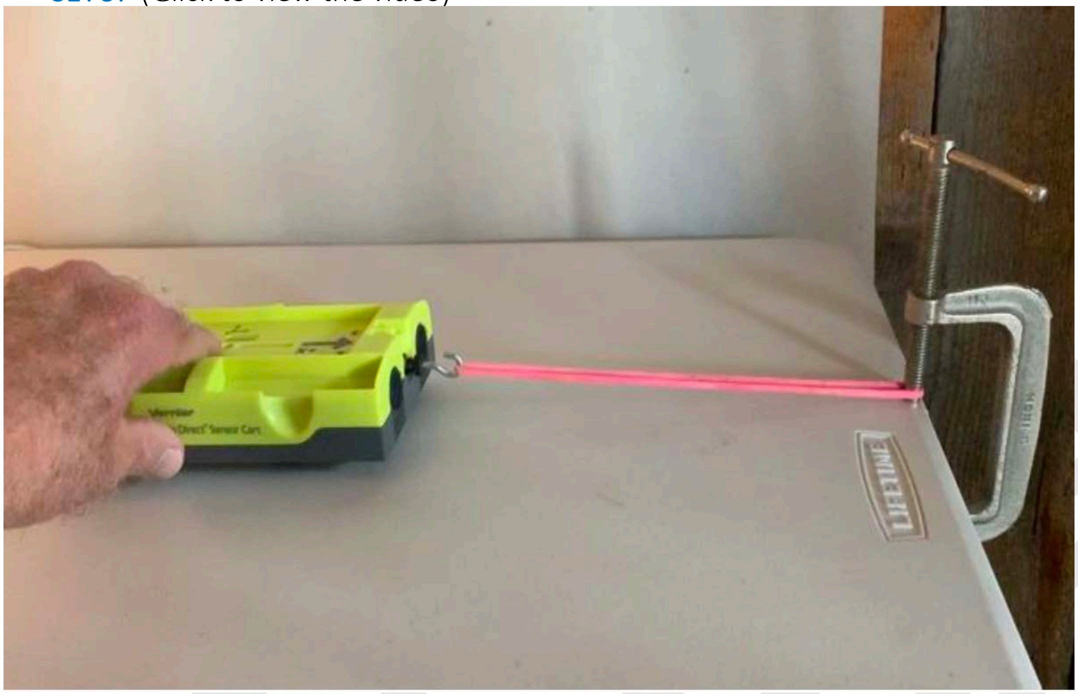
RESEARCH QUESTION

What mathematical function best describes the relationship between the applied force and the resulting amount of stretch of a rubber band?

PREDICTED OUTCOME

EXPERIMENTAL DESIGN

SETUP (Click to view the video)



With the rubber and attached but not under stress, zero the Force and Position Sensors. Tap 'Collect' and collect both force and position data.

MATERIALS Sensor Cart with hook, rubber band, C-clamp

PROCEDURE (Designed with student team collaboration)

ANALYSIS (Include graphs and sample calculations)

CONCLUSIONS (Respond to the research question, include results with error analysis)

EXTENSIONS (Questions for further research)

INVESTIGATION 18

Kinetic Energy and Momentum: *Elastic Collisions*

INTRODUCTION

A perfectly elastic collision between two or more objects is one in which there is no loss in kinetic energy and do not exist in our human-sized macroscopic world. Billiard balls, however, have an elasticity above 90%. You can hear the click sound when billiard balls collide, and with a sensitive infra-red camera you may detect a warming of the colliding balls. This indicates a transformation of kinetic energy into sound and heat energy. On the other hand, collisions between atmospheric gas molecules are perfectly elastic. This is one of the assumptions of The Kinetic Molecular Theory. Unlike collisions between billiard balls the average molecular speed of gas molecules is not reduced when they collide. If collisions between gaseous molecules were not perfectly elastic their speeds would diminish, and our atmospheric gases would soon become liquid. That would be fatal for humans and other animals who require gaseous oxygen. Here you can explore a simulation of perfectly elastic particle collisions.

In this investigation you are to setup two carts with magnets or hoop springs attached to the force sensor of each cart. The magnets must be oriented to repel each other to provide a highly elastic collision. With both cart's Motion Encoders activated, you will measure the velocity of both carts as they collide. Knowing the mass and velocity of both carts you can determine whether momentum ($\mathbf{P} = m\mathbf{v}$) and/or kinetic energy ($KE = ½ mv^2$) is conserved during this nearly elastic collision.

After setting up your carts and before collecting data, explore the interactions of the colliding carts when their masses are equal and when the incoming cart has both more and less mass than the initial stationary cart.

Kinetic energy and momentum are both calculated using measurements of mass and velocity. Could it be that one of these quantities is conserved during elastic collisions and the other is not? Describe and explain your reasoning for your prediction.

RESEARCH QUESTIONS

1. Is kinetic energy or momentum conserved during the elastic collision between two carts of equal or mass?
2. Is kinetic energy or momentum conserved during the elastic collision between two carts when their masses are not equal?

PREDICTED OUTCOME

EXPERIMENTAL DESIGN

SETUP (Click to view event)

Two carts of equal mass equipped with magnets experience an elastic collision.

MATERIALS 2 Sensor Carts, magnets or hoop springs, 4 – 8 cart masses,
A smooth level table or track

PROCEDURE (Designed with student team collaboration)

ANALYSIS (Include graphs and sample calculations)

CONCLUSION (Respond to the research question, include results with error analysis)

EXTENSIONS (Questions for further research)