NSTA 2024
Denver, CO

On the Right Track: Hands-On Explorations of Motion and Force

Experiments

Motion on an Incline: *Coasting Up and Down*

- Go Direct Sensor Cart

Investigating Friction

- Go Direct Sensor Cart

Hooke's Law: *Stretching Rubber Bands*

- Go Direct Sensor Cart

Workshop Presenter

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INVESTIGATION 3

Motion on an Incline: *Coasting Up and Down*

INTRODUCTION

Skateboarders and snowboarders must have the most experience and understanding of the sensations encountered during half-pipe rides. They know when to expect maximum forces and points of weightlessness. Some roller coaster rides offer similar experiences to the passengers but not with the repetitiveness encountered by boarders who have mastered the half-pipe. You might wonder how professional boarders like Shaun White are able to increase their height above the pipe's rim as they make their way down the slope. Whether half-pipe riders know it or not they are using two basic physics principles, the Conservation of Energy and the Conservation or Rotational Momentum. Riders on half-pipes add energy to the system by pumping their legs and arms. The physics of skateboarding on half-pipes is more fully explained here. These principles will be studied later in your physics course but for now understanding position, velocity and acceleration graphs of carts rolling up and down an incline will assist with understanding the great conservation laws of physics.

In this lab you will collect position, velocity and acceleration data as you observe the Sensor Cart coasting up and down an incline.

Before collecting data, observe your Sensor Cart rolling up and down the incline, then sketch graphs of your predictions for the shape of position vs. time, velocity vs. time and acceleration vs. time graphs that describe the motion of the cart.

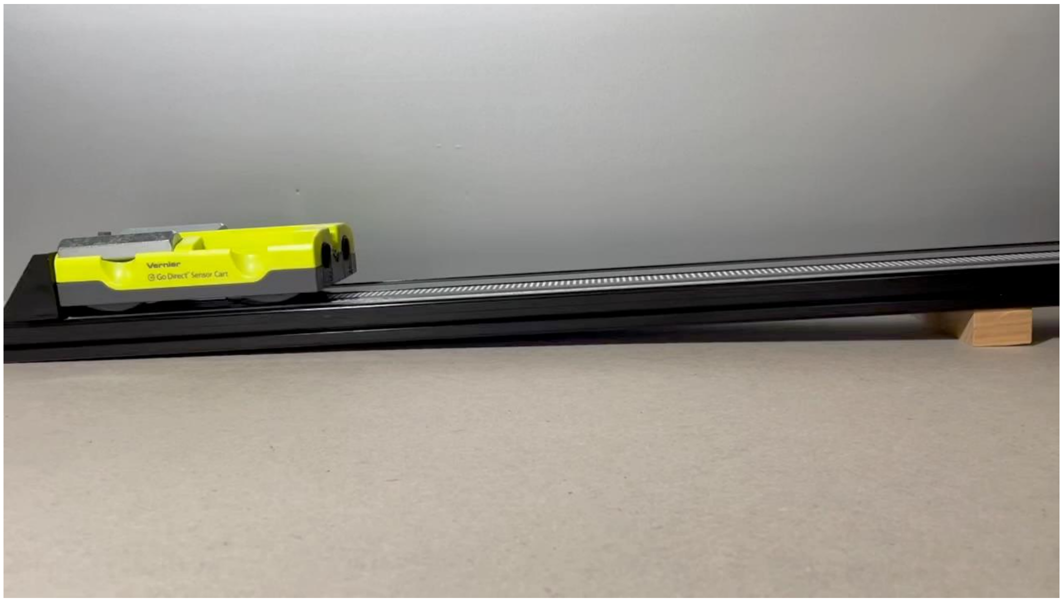
RESEARCH QUESTIONS

1. When the cart rolls up and down the incline where on the ramp will the speed of the cart be zero?
2. Where on the ramp will the cart be traveling with maximum speed?
3. How does the acceleration of the cart coasting up the ramp compare to the value when coasting down?

PREDICTED OUTCOME

EXPERIMENTAL DESIGN

SETUP (Double click to view the event)



The sensor cart's plunger launches the cart. It then coasts up and down the incline.

MATERIALS Sensor Cart, tilted track with end stop

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)

Investigating Friction

Friction is a force that resists motion. It involves objects in contact with each other, and it can be useful or harmful. Friction helps when you want to slow or stop a bicycle, but it is harmful when it causes wear on the parts of a machine. In this activity, you will study the effects of surface smoothness and the nature of materials in contact on sliding friction. You will use the force sensor built into a Go Direct Sensor Cart to measure frictional force as you pull a block across different surfaces.

OBJECTIVES

- Measure friction between a wooden block and smooth-surface wood.
- Measure friction between a wooden block and rough-surface wood.
- Make predictions about other surfaces.
- Test your predictions.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis app
Go Direct Sensor Cart
wooden block (with a hook)
loop of string or paper clip
wood with smooth surface
wood with rough surface
sandpaper

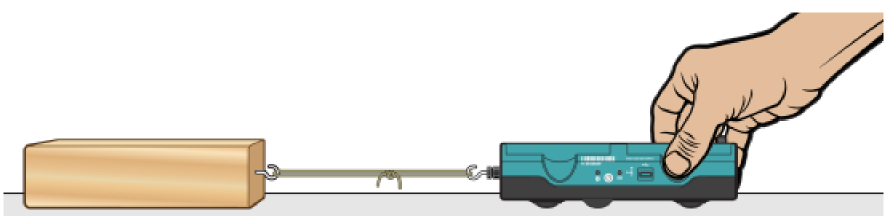


Figure 1

PROCEDURE

Part I Smooth and rough surfaces

1. Launch Graphical Analysis. Connect the Go Direct Sensor Cart to your Chromebook, computer, or mobile device. Click or tap Sensor Channels, deselect Position, and select Force. Click or tap Done.

2. Click or tap Mode to open Data Collection Settings. Change End Collection to 3 seconds. Click or tap Done.

3. Set the Sensor Cart on the tabletop in the position shown in Figure 1. Making sure nothing is touching the hook, click or tap the Force meter and choose Zero to zero the force sensor.

4. Get a wooden block that has a hook on one end. Connect the wooden block to the Sensor Cart using the loop of string (see Figure 1). Use a paper clip if you do not have a loop of string.

5. Slowly pull the wooden block across a piece of wood with a smooth surface. Hold the cart by its sides and pull it toward you (see Figure 1). Once the wooden block is moving at a steady rate, click or tap Collect to start data collection. Continue pulling the wooden block until data collection is complete.

6. Determine the mean (average) force (in N).

   a. After data collection is complete, click or tap Graph Tools, , and choose View Statistics.
   b. Record the mean force.

7. Repeat Steps 5–6 as you pull the block over a piece of wood with a rough surface.

Part II Predicting friction

8. You will measure friction as the block is pulled across your desk top, the floor, and sandpaper. In the blanks supplied in the data table, predict the order of friction for these surfaces, from least to most.

9. Repeat Steps 5–6 for each of the surfaces.

DATA

Part I Smooth and rough surfaces		
Surface	Smooth wood	Rough wood
Force (N)		

Predicted order of friction values for the desk top, the floor, and sandpaper:		
______________	______________	______________
least friction		most friction

Surface	Desktop	Floor	Sandpaper
Force (N)			

PROCESSING THE DATA

1. What is the effect of surface roughness on friction?
2. How did you decide the order of your predictions in Part II?
3. How good were your predictions? Explain.
4. Give two examples of situations where friction is helpful.
5. Give two examples of situations where it is best to reduce friction.
6. Summarize the results of this experiment.

EXTENSIONS

1. Test the friction of other surfaces, such as glass, metals, rubber, and different fabrics.
2. Investigate either the relationship between frictional force and contact area or frictional force and mass.
3. Design an experiment to test methods of reducing friction.

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 being stretched? 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.

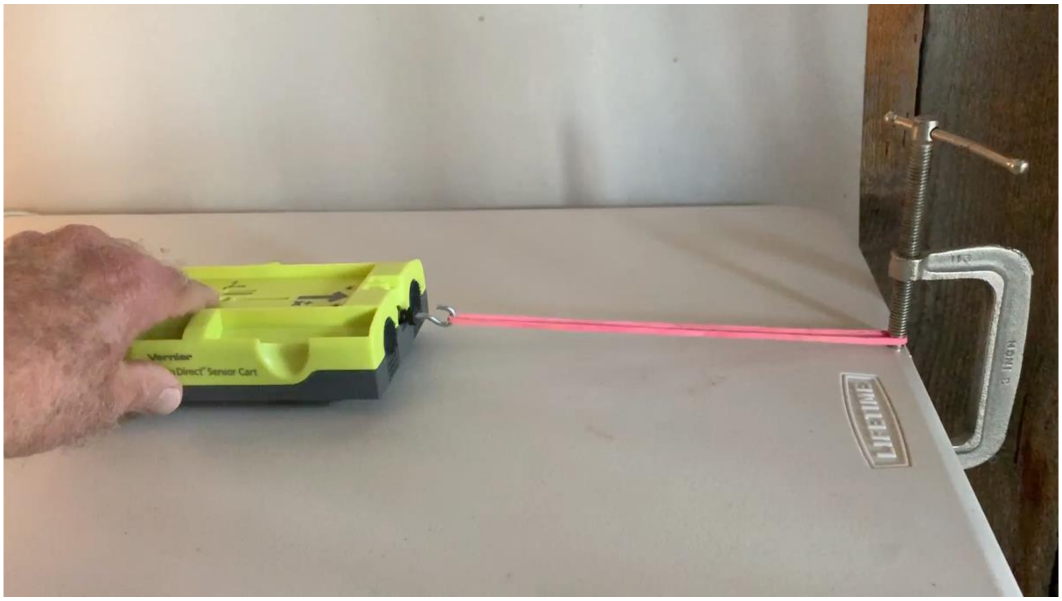
RESEARCH QUESTION

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 (double 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)