

Investigation 5.2.1 CONTROLLED EXPERIMENT

SKILLS MENU

- | | | |
|-----------------|-------------------------|-----------------|
| • Questioning | • Planning | • Observing |
| • Researching | • Controlling Variables | • Analyzing |
| • Hypothesizing | • Performing | • Evaluating |
| • Predicting | | • Communicating |

Conservation of Energy

In this investigation, you will explore what happens to the gravitational potential energy, kinetic energy, and total mechanical energy of a cart as it rolls down a ramp.

Testable Question

What are the relationships between

- gravitational potential energy and position
- kinetic energy and position
- total mechanical energy and position

for a laboratory cart rolling down a ramp?

Hypothesis/Prediction

Make hypotheses based on the Testable Question. Your hypotheses should include predictions and reasons for your predictions.

Variables

Read the Testable Question, Experimental Design, and Procedure, and identify the manipulated variables, responding variables, and controlled variables in this experiment.

Experimental Design

In this experiment, you will place a motion sensor at the top of a ramp and use the sensor's software to sketch a position–time graph of a laboratory cart as it rolls down the ramp. You will use one position near the end of the relevant data as the final position or reference point. You will use other positions to find the height and speed of the cart. You will then use these data to calculate the gravitational potential energy, kinetic energy, and total mechanical energy of the cart. Finally, you will look for patterns in these data to complete the experiment.

Equipment and Materials

- eye protection
- ramp
- 3–4 textbooks or wood blocks
- metre stick
- motion sensor
- laboratory cart

Procedure

SKILLS
HANDBOOK A2.2

1. Prop up one end of a ramp using textbooks or wood blocks. Use a metre stick to measure the length of the ramp (L) and the height of the ramp (H) as shown in **Figure 1**.
2. Place the motion sensor at the top of the ramp, directed toward the bottom. Release the cart from a position near the motion sensor. Obtain the position–time graph of the cart as it rolls down the ramp away from the motion sensor.
3. Choose one point on the position–time graph near the end of the run. The position coordinate \vec{d}_2 and the reference point that will be used to determine the height of the cart ($h = 0$ at the reference point). This point will not change throughout the experiment.
4. To find the height of any other position above the reference point, examine Figure 1. The ramp itself forms a larger triangle and the displacement of the cart down the ramp forms a smaller, similar triangle. Using these similar triangles, we have

$$\frac{h}{\Delta d} = \frac{H}{L}$$

$$h = \Delta d \left(\frac{H}{L} \right)$$

This equation will be used to calculate the height, h , of the cart on the ramp.

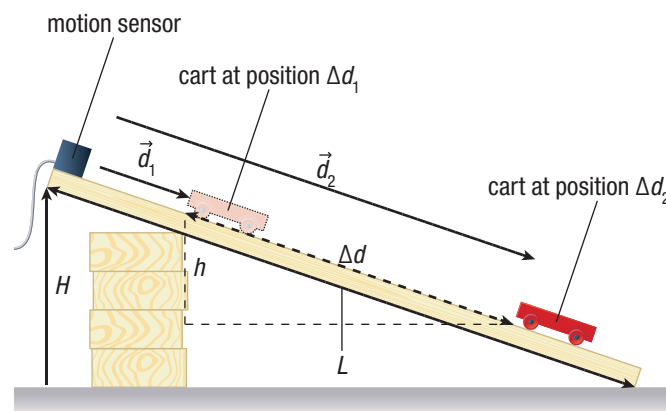


Figure 1

5. To determine the speed at any point on the position–time graph, use the slope tool in the program for the motion sensor.
6. Starting with a point near the start of the run, determine the position, \vec{d}_1 , and the speed, v , at this point. Use these values to complete the first row of **Table 1**.
7. Use other positions from the graph to complete the next three rows in Table 1. These positions should get gradually closer to the final position.

Table 1 Data for Conservation of Energy Investigation

Initial position	Variable							
	\vec{d}_2	\vec{d}_1	$\Delta d = \vec{d}_2 - \vec{d}_1$	h	v	E_g	E_k	E_m
1								
2								
3								
4								

Analyze and Evaluate

- (a) What variables were measured and manipulated in this investigation? What relationships, based on the Testable Question, were tested?
- (b) Calculate the cart's gravitational potential energy, E_g , kinetic energy, E_k , and total mechanical energy, E_m , for each initial position in Table 1. T/I

- (c) Answer the Testable Question. T/I
- (d) What effect does friction have on the different types of energy in this experiment? Use an FBD and the concept of work to explain your reasoning. T/I C
- (e) What are some possible sources of error? T/I
- (f) Evaluate your hypotheses. How did your hypotheses compare to the results of the experiment? T/I
- (g) What energy changes take place in this experiment? What evidence have you found that almost no energy is lost in this experiment? T/I
- (h) Why is it essential to keep the final position, \vec{d}_2 , fixed for the entire investigation when testing conservation of energy? T/I
- (i) In your own words, explain how to determine the height of the cart above the final position using the position–time graph. T/I C

Apply and Extend


- (j) Imagine doing the experiment again with one change: starting the cart at the bottom and launching it up the sensor. You may assume the cart does not hit the sensor. How would the initial speed up the ramp compare to the final speed down the ramp at the same position? Explain your reasoning. T/I

Investigation 5.5.1 OBSERVATIONAL STUDY

SKILLS MENU

Student Power

In this investigation, you will explore your own personal power using different types of fitness equipment. To calculate your power, you will first determine how much work you have done while performing different exercises.

You must measure your own work and power while performing exercises for brief and long periods of time. The brief activity can last for 10 s and the long activity will last for 2 min. The activities should involve two types of fitness equipment—one that uses mainly arm muscles and another that uses mainly leg muscles. Keep safety in mind when selecting exercises. Perform exercises at a comfortable level rather than pushing yourself to find maximum power. 

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You should never use any fitness equipment without being instructed on how to use it safely. Always get your teacher's approval before using any equipment. Notify your teacher of any health problems that may prevent you from completing this activity safely. Be careful when lifting weights and avoid fast movements.

Purpose

To determine how the power of your legs compares to the power of your arms for different exercises, and to observe how the amount of work changes as the duration of an exercise increases