SMART CART – CONSERVATION OF ENERGY

Driving Question | Objective

How does the mechanical energy of a cart change as its motion changes due to gravity? Perform an experiment that explores how a cart's kinetic energy, gravitational potential energy, and total mechanical energy change as it rolls up and down an inclined track under the force of gravity.

Materials and Equipment

- PASCO Smart Cart
- PASCO Dynamics Track with feet
- PASCO Dynamics Track End Stop
- PASCO Angle Indicator
- 3 Textbooks to set track on
- Balance, 0.1-g resolution, 2,000-g capacity (1 per class)

Background

Mechanical energy is described as the energy associated with an object's motion and position. An object on earth, isolated from any outside influences, experiences two forms of energy that both contribute to the object's total mechanical energy: gravitational potential energy U_g, and kinetic energy K. The object's total mechanical energy E is equal to the sum of its gravitational potential energy and kinetic energy:

$$E = U_g + K \tag{1}$$

Gravitational potential energy is described as the energy stored in an object due to the attraction from earth's gravitational field. This energy is based on the object's mass m, height y, and earth's gravitational acceleration g:

$$U_g = mgy \tag{2}$$

An object's kinetic energy is described as the energy stored in the object due to its motion. This energy is based on the object's mass m and speed v. As an object's speed increases, its kinetic energy K increases in the form:

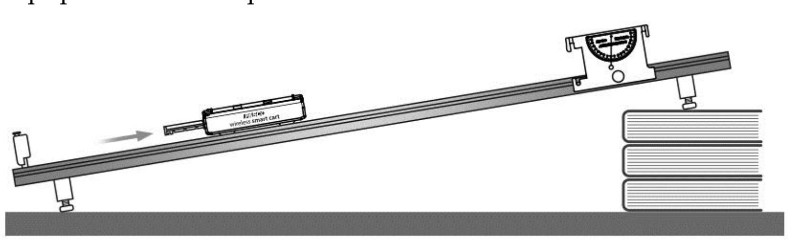
$$K = \frac{1}{2}mv^2 \tag{3}$$

In this lab activity you will measure the height and speed of a cart as it moves along an inclined track under the force of gravity. Using those measurements, calculate the cart's kinetic and gravitational potential energy and explore the relationships between them and the cart's total mechanical energy as the cart's motion changes due to the applied force from gravity.

Procedure

SET UP

1. Assemble your equipment like the picture. The track should have an incline of about 10°.



2. Open the experiment file **SC Conservation of Energy**, and then power-on the Smart Cart and connect it wirelessly to your software.

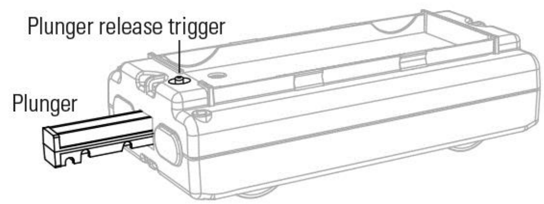
3. In the experiment file is a graph of the cart's position and velocity versus time.

COLLECT DATA

4. Use the balance to measure the mass of the cart. Record this mass above Table 1 in the Data Analysis section below.

5. Observe the angle indicator. Record your track's incline angle above Table 1.

6. Press the plunger on the cart all the way into the cart until it locks in place, and then set the cart at the bottom of the track with the plunger facing the end stop.



7. Begin recording data, and then tap the plunger release trigger to launch the cart up the track.

8. Allow the cart to roll up and back down the track, and then catch the cart just before it hits the end stop. Stop recording data.

Data Analysis

Mass of Smart Cart, m (kg): ______________________

Track incline angle, θ (°) ______________________

Table 1: Mechanical energy of a cart rolling up and then down an inclined track under gravity

	Speed, v (m/s)	Distance, d (m)	Height, y (m)	Potential Energy, U_g (J)	Kinetic Energy, K (J)	Mechanical Energy, E (J)
Point 1						
Point 2						
Point 3						

❓ 9. Observe the cart's velocity-time data in the graph. Identify the section of data where the cart was rolling freely up and back down the track. Explain how you identified this section of data.

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10. In the section of data where the cart was rolling freely up and back down the track, choose 3 arbitrary data points: one point while the cart's velocity was positive, one point while the cart's velocity was negative, and one point while the cart's velocity was zero or nearly zero.

11. Use the tools in your software to determine the cart's speed v and corresponding distance d up the track at those three points in time, where:

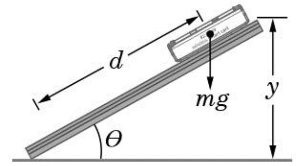
$$v = |\text{velocity data}|$$

$$d = \text{position data}$$

Record the cart's speed and distance at each data point into Table 1.

12. Assuming the cart's height was zero before it was launched, calculate the cart's height y at each of the three points, where:

$$y = d\sin(\theta)$$



Record your results into Table 1.

13. Use the values from and above Table 1, along with equations 1, 2, and 3 to calculate the cart's potential energy U_g, kinetic energy K, and total mechanical energy E at each of the three points. Record your results into Table 1. Assume $g = 9.81\ \text{m/s}^2$.

Analysis Questions

1. How does your cart's potential and kinetic energy compare at the three different points? Explain why the values are different or similar between the three points.

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2. How does your cart's total mechanical energy compare at the three different points?

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3. Does your data show that the cart's total mechanical energy was conserved as the cart rolled up and back down the track? Justify your answer.

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