INVESTIGATION 18

Elastic PE to KE: *Launch Speed*

INTRODUCTION

The historical development of the law of conservation of energy is an interesting story which evolved between 1798 and 1850. Without the concept of energy, science and technology would have progressed at a much slower rate. In Investigation 17 you measured the amount of elastic potential energy stored in the Sensor Cart's fully compressed plunger spring. You will now use your value of the energy stored in the plunger spring with the law of conservation of energy to predict the speed of the Sensor Cart following the release of the plunger spring. With this knowledge you can calculate the energy required to make a rocket car go 1,000 mph.

When the energy stored in the plunger spring is released into a fixed barrier, the potential energy is transferred into the cart as kinetic energy. To calculate your predicted cart speed, set your value for the elastic potential energy stored in the plunger spring equal to the equation for kinetic energy ($PE_{elastic} = \frac{1}{2} mv^2$). Measure the mass of the cart then solve for 'v', the maximum speed of the cart. Be sure to use SI units. This theoretical value serves as your prediction for the cart's speed. Record your prediction for the speed of the cart.

The Sensor Cart with its compressed plunger spring is set against a fixed barrier as shown in the event displayed below. Plan a procedure with your lab team to respond to the Research Question.

Finally, compare your predicted theoretical cart speed, to your experimental measured cart speed. How well do the two speed values compare? What is the percent error between the theoretical and experimental values?

RESEARCHQUESTION

What will be the launch speed of the Sensor Cart when its fully compressed plunger spring is fired against a fixed barrier?

PREDICTED OUTCOME (Make your prediction based on the Law of Conservation of Energy)

EXPERIMENTAL DESIGN

SETUP

With the cart resting against a fixed barrier on a level track, launch the cart by tapping the plunger spring release button with your finger or a lightweight hammer.

MATERIALS Sensor Cart, level table or track, hammer (optional), end stop barrier

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)

SAMPLE CALCULATIONS

PE plunger	Cart Mass	V Theoretical	V Measured	% Error
Investigation 16	Measured	V =sqrt(2*PE/m)	v - t graph	%E=(T-M)/T
J	kg	m/s	m/s	%
0.094	0.288	0.809	0.752	7.01%

The theoretical velocity is calculated from equating the $PE_{plunger}$ to KE_{cart} ($PE = ½ mv^2$), and solving for 'v', (v = sqrt(2*PE/m)). It is not surprising that the predicted, theoretical speed is 7% greater than the measured speed. You have learned the Sensor Cart wheels do have some friction and compressed and stretched elastic material lose energy. Thus, some of the plunger spring potential energy has been converted into an unmeasurable amount of heat energy.

If you would like a second way to measure the speed of the Sensor Cart use the Video Analysis App from Vernier. Using two different approaches to make the same measurement can provide a sense of confirmation.

INTERNET REFERENCES

1,000 mph Rocket Car: https://www.youtube.com/watch?v=3[illegible]QOWYkJSzI

History of conservation of energy: https://en.wikipedia.org/wiki/Conservation_of_energy

Fundamental SI units and derived units: https://physics.nist.gov/cuu/Units/units.html

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Measuring the speed of the Sensor Cart when launched with its fully compressed plunger spring is very straight forward. Turn on your Sensor Cart and launch Graphical Analysis. Select your Sensor Cart. The position sensor is activated by default. Both a position vs. time and velocity vs. time graph will be displayed. As always, zero the position sensor before each run. Students can either select the Tangent line or Apply a Linear Curve Fit to the position vs. time graph to determine the speed of the cart. The Examine tool can be used to display the maximum speed of the cart on the velocity vs. time graph. Note, a tap of a finger can easily fire the plunger spring, a hammer is not required.

SAMPLE DATA

The above graphs display the change of position and velocity of the Sensor Cart following the release of potential energy stored in the cart's compressed plunger spring. The Sensor Cart's maximum velocity is shown to equal 0.752 m/s on both of the above graphs. The compressed plunger spring in Investigation 17 was found to have an elastic potential energy of 0.094 N·m. The equation KE = PE_{spring}, shows the predicted maximum speed of the cart when launched by its plunger spring to be: v_{max}=0.809 m/s.