**Conservation of Energy: The Ramp**

**Background**

In the previous lab you considered Conservation of Mechanical energy, which is comprised of both kinetic energy (the energy of motion) and potential energy (the energy of position). In this lab you’ll also consider another potential energy: *elastic potential energy*.

Elastic potential energy is the energy stored in things that can compress or stretch - think of springs and rubber bands. In fact, if you consider a spring, you’ll realize that there are different types: a slinky is a very loose spring, but old screen doors have a very tightly-wound and strong spring on them. As such, the amount of energy that can be stored in a spring depends on what type of spring it is. A coefficient known as the *spring constant* and represented by  describes the stiffness of the spring - more stiff springs will have a higher spring constant. The energy also depends on how far the spring/elastic is stretched or compressed, . When we combine these variables, we can express the elastic potential energy as

.

In this lab you will spring launch a cart on an inclined plane. The spring will provide the elastic potential energy, gravitational energy matters because the cart is gaining altitude, and kinetic energy exists any time the cart is moving.

When the cart is released from the spring, it will travel up the ramp. As it does so, it will slow down and eventually come to a stop. The car will go back down the ramp, bounce and repeat this process a couple of times, and finally come to rest. A motion sensor is used to monitor the position of the cart.

MEi

MEf

h

d

**Goal:** The purpose of this experiment is to measure mechanical energy (kinetic, gravitational potential, and elastic potential energies) and determine when mechanical energy is conserved in a system.

**Part I - Determining the Spring Constant**

Before you can use the spring to test the conservation of mechanical energy, the spring constant for the cart must be determined.

* Attach an Angle Indicator to the side with the adjustable leg and make sure that your dynamics track is level.
* Place a Motion Detector on that side of the track and connect it to Capstone.
* Attach a Spring Cart Launcher to a Pascar.
* Attach a Dynamics Track End Stop on the other end of the track.
* Take the stiffest spring and put it on the rod of the spring cart holder. Put the narrow end of the spring against the car. Put the rod through the Dynamics Track End Stop.
* Take a paperclip and thread it through the end of the rod so the paperclip is horizontal. Place a hook on a force sensor, connect the force sensor to Capstone. Press Record, pull on the force sensor, compressing the spring
* Use Capstone to create a table and a graph of the force versus compression data. The slope of this data is the spring constant, k. (Don’t forget to tare the force censor before each data run.)

k = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (N/m)

**Part II - Measuring Energies**

Now that the spring constant is known, the energy of the system can be examined, both at the bottom of the ramp where the potential energy is zero as well as at the top of the ramp where the kinetic energy is zero.

Just one note: be sure to brace the bottom end of the track. As the cart bounces after release, it can move the entire system and convolute your data. A heavy textbook or backpack to brace the track will do the trick.

* Raise one end of the track and determine the angle. Use your Angle Indicator to measure this to the nearest degree.

 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Take the paper clip off the end of the rod. Pull back on the rod and see how much you need to pull back to have the cart go past the center of the track, but not go within 20 cm of the force sensor. Press the ***Record*** button in Capstone and shoot the cart up the track. Allow the cart to bounce until it comes to rest. Then, ***Stop*** recording data. Enter your measurements and complete the calculations in the table shown. Note: the percent difference is defined as the difference of two measurements divided by the mean, or 

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Trial #1 | Trial #2 | Trial #3 |
| Measured |  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Calculated |  |  |  |  |
|  |  |  |  |
| *h = d* sin θ |  |  |  |
|  |  |  |  |
| at |  |  |  |
| at |  |  |  |
| % Difference in ME |  |  |  |

**Summary Questions**

1. What is the  of the fully compressed spring?
2. Remember that Mechanical Energy can be written as the sum



What is the total mechanical energy just after the spring is released? Assume that  initially. What is your percent loss/gain of energy between your mechanical energy before the spring is released and after the spring is released? You may get losses of up to 50%. Where did this energy go?

1. While the cart is moving on the track, one would expect conservation of mechanical energy. Does your data show that? To find out, calculate the total mechanical energy when the cart is at the top of the ramp (where the kinetic energy is zero) and the total mechanical energy when the cart is at the bottom of the ramp (where the potential energy is zero).
2. Once the cart bounces, it doesn’t travel up the ramp as far as it did the time before. How much energy is “lost” on a bounce? What is the percent difference between energy before the bounce and energy after the bounce?

**Energy Questions**

1. If a 50.0-gram mass was lifted on a pendulum so its height is 2.00 cm higher than when it is at equilibrium, what is its velocity as it goes through the equilibrium point?

Now double the height that you lift the pendulum (to 4.00 cm). How many times faster (or slower) is your mass traveling as it passed through the equilibrium point?

1. You drop the bouncing ball from a height of 1.00 m and it rebounds to 0.50 m. What percentage of original energy does the ball have after it bounces?

Now assume you are dropping the ball from 2.00 m. Using the same percentage of energy the ball has after the bounce, calculate the new height the ball will reach.