Experiment 3: Conservation of Mechanical Energy

Mihir Mathur
204 612 694

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TA: Krishna Choudhary
Lab Partners: Michael Arreola-Zamora, Jonathan Zatur
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Discussion

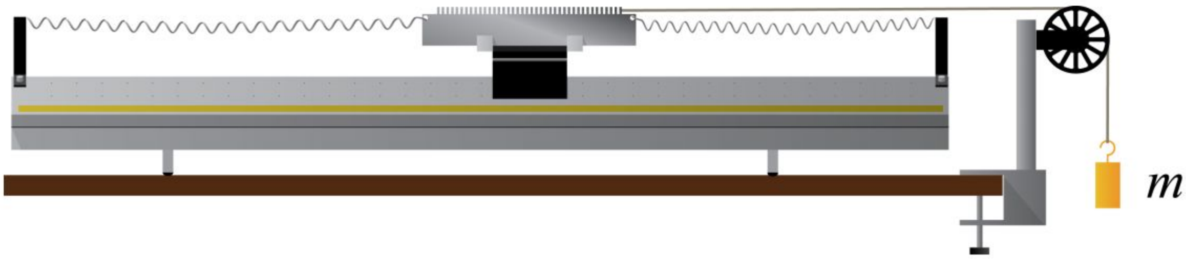

Figure 3.1 Experimental setup for calculating spring constant. The hanging mass is removed to perform experiment for calculating total mechanical energy.

The photogate was aligned slightly to the left of the 30th tooth of the comb at the glider's equilibrium position. I aligned it this way because the 30th tooth was right in the middle. The glider was pulled towards the left each time.

First, the spring constant was calculated by obtaining the slope of the applied force versus displacement of glider graph (Figure 3.2) since the force applied is given by the equation: $F = kx$ where k is the spring constant and x is the displacement from equilibrium position.

For calculating the kinetic and potential energies in the same positions in space, first the readings of the block count and block event times were recorded using the DAQ. Then the position was calculated for each time by using the fact that each tooth of the photogate comb and each space between the teeth is $2\text{mm} \pm 30\mu m$. The position at the 30th tooth was considered as 0 since that is the equilibrium position. The positions increment by 4mm for each count.

The potential energy, was calculated using the formula: $E_p(\overline{x}(i)) = \frac{1}{2}k\overline{x}_i^2$ where $\overline{x}(i)$ is the average position in the interval and k is the spring constant which was found to be $k = 6.18 \pm .01\ N/m$.

For calculating the kinetic energy, the velocity was calculated first by differentiating the position with respect to time: $v(\overline{x}(i)) = \frac{\Delta x}{\Delta t} = \frac{x_{i+1}-x_i}{t_{i+1}-t_i}$

Thus,

$E_k(\overline{x}(i)) = \frac{1}{2}M(\frac{x_{i+1}-x_i}{t_{i+1}-t_i})^2$

For each position in space, E_k and E_p was plotted (Figure 3.3). The potential energy is an upward facing parabola while the kinetic energy is a noisy downward facing parabola. The total mechanical energy i.e. the sum of E_k and E_p is linear with a very small slope. The slight loss in total energy is because of the dissipation as heat due to friction.

Plots and Tables

Mass of glider with photogate comb: $.2265 \pm .00005$ kg

Hanging Mass (kg)	Applied Force (N)	Displacement of glider (m)
$0.0998 \pm .00005$	$0.9780 \pm .0005$	$0.153 \pm .0005$
$0.0811 \pm .00005$	$0.7947 \pm .0005$	$0.124 \pm .0005$
$0.0603 \pm .00005$	$0.5909 \pm .0005$	$0.091 \pm .0005$
$0.0358 \pm .00005$	$0.3508 \pm .0005$	$0.052 \pm .0005$
$0.0208 \pm .00005$	$0.2038 \pm .0005$	$0.028 \pm .0005$

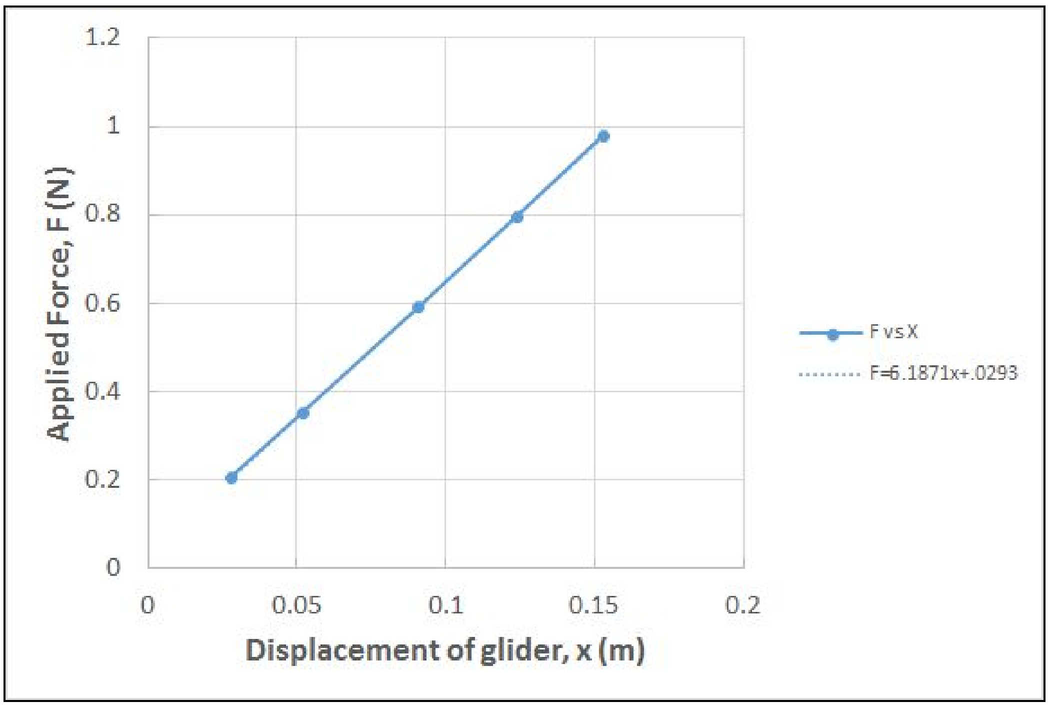

Figure 3.2 Determining spring constant of a combination of springs by hanging a mass over a pulley and taking the measurement of the displacement of the glider. The spring constant found in this case was $k = 6.18 \pm .01\ N/m$

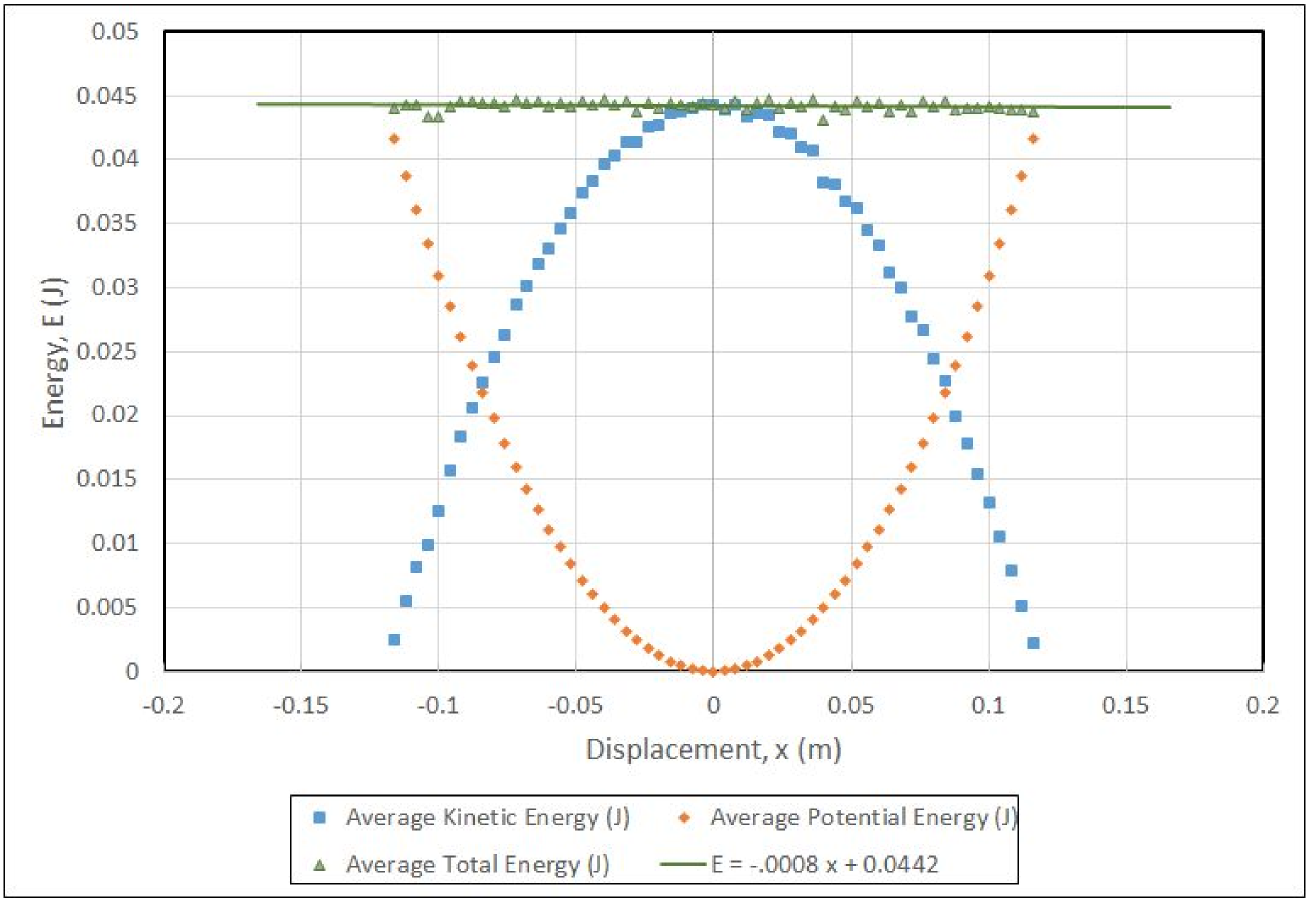

Figure 3.3 Kinetic energy, potential energy and total mechanical energy of a glider attached to springs at different positions for verifying conservation of energy. The kinetic energy was calculated by differentiating the position with respect to time and using the formula $E_k = \frac{1}{2}mv^2$. The potential energy was calculated by using the formula $E_p = \frac{1}{2}kx^2$. The slope of the best fit line for the total energy is $-.0008 \pm .0002$ J/m

Calculation for coefficient of friction:
The slope of the total energy best fit line represents the loss in energy per metre. This is equal to the frictional force exerted.

Slope $= \mu *$ Normal Force
The normal force is equal to the weight of the glider.
Here,
slope $= -.0008 \pm .0002$ J/m
Normal force = mass of glider * g = $(.2265 \pm .00005) * 9.8 = 2.219 \pm .0005$ N
$\mu = \frac{Slope}{Normal} = .0003 \pm .00007$

The extremely small value of coefficient of friction agrees with the expected result since the airtrack is supposed to have an almost zero coefficient of friction, due to which loss of energy is minimal.

Presentation Mini-Report

Verification of Conservation of Mechanical Energy

Mihir Mathur[1]

Mechanical energy in a spring-mass system is said to be conserved in newtonian physics. In this experiment, a glider with a photogate comb attached to a spring and freely moving on an airtrack was investigated and it was verified that the total mechanical energy is conserved. To verify the conservation of energy, first, the spring constant was calculated by obtaining the slope of the applied force versus displacement of glider graph. Then the position and time was recorded for one half oscillation of the glider. Using the known measure of the distance between the photogate teeth, the displacement was calculated and then differentiated with respect to time to calculate the velocity. With the values of velocity, displacement and spring constant, the kinetic energy and potential energy at each displacement was calculated and a graph was plotted. From the graph, it can be clearly verified that the total energy decreases very slightly. This decrease can be attributed to the heat loss due to friction. This experiment was performed for furthering my knowledge of physics by learning the experimental procedures for verifying that potential energy and kinetic energy interchange as the glider moves, but the total energy is conserved.

[1]Henry Samueli School of Engineering and Applied Science, University of California Los Angeles