**“Experiment 3: Conservation of Mechanical Energy”**

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**Worksheet:**

**2. Discussion**

The comb was set up so that, at equilibrium, the comb’s 31st tooth, counting from the left, is on the verge of blocking the photogate sensor on its left side. With this setup, the 31st tooth would immediately trigger the photogate’s sensor if the comb was removed from equilibrium by being pulled to the left. To simplify calculations, for the duration of the experiment the glider was pulled to the left so that the 31st time stamp would be the equilibrium time stamp. This information was used to interpret the raw timestamp data as a function of position. With our set up, the first timestamp is at position 0.124m, the 31st time stamp is at position 0 and so on.

For a position, x, the kinetic and potential energies were calculated by finding the spring constant, k, of the springs, the mass, M, of the glider and then using Equation 3.1:

and Equation 3.2:

from the lab manual.1 Where U is the potential energy and K is the kinetic energy. *v* was calculated by numerical differentiating the data. In order to calculate the potential and kinetic energies at the same position in space, each data point if for a position and time hallway in-between each pair of adjacent data points. By averaging adjacent data points, the data set was halved, but it allowed for numerical differentiation which was needed to calculate the velocity of the glider at each point.

**3. Plots and Tables**

The mass of the glider with the comb attached was found to be 225.0 ± 0.5 g.

Figure 1: Derivation of Spring Constant by Mass Suspension A scatterplot showing the glider’s displacement from equilibrium as increasing forces are applied through the pulley system. The forces were calculated by multiplying the mass suspended, m by the gravitational acceleration, g. The trend is linear, the fit line being of the form y=ax+b where a=5.8337 and b=0.0005. The spring constant, k, is therefore given by the coefficient a, with the uncertainty being calculated using the linear regression tool in excel. This value for k was therefore found to be k=5.83 ± 0.2 N/m.

In Figure 1, the derivation of the spring constant k is shown. Through the analysis of the linear relationship between the varied forces and the displacement of the glider from equilibrium, k was found to be 5.83 ± 0.2 N/m.

Figure 2. Energy Distribution and Loss due to Friction for the Oscillating Glider Shown are scatterplots showing the potential, kinetic, and total energies present in the glider spring system throughout half an oscillation. The kinetic energy is represented by the blue dots. The kinetic energy resembled a downward facing parabola. The potential energy is represented by the orange dots and resembles an upward facing parabola. The kinetic energy has more noise than the potential energy because the kinetic energy was calculated using velocities, which were found by numerically differentiating the raw data which causes noise. The total mechanical energy, which is the sum of the potential and kinetic energies, is given by the grey dots. This total energy data has a more linear relationship, as expected, since, ignoring loss, the total kinetic energy in a system should remain constant. The data for the total mechanical energy has a solid grey linear fit line of the form y=ax+b where a= -0.0004 and b=0.0466. The slope of this fit line means that there is a downward trend in the total mechanical energy, which implies a loss of energy due to friction. The coefficient of friction of the glider on the air track was calculated to be 0.0002 ± .001.

**4. Extra Credit**

Figure 3. Energy Loss of the Glider System through Two Oscillations The orange scatterplot shows the potential energy fluctuations over time and resemble upward-facing parabolas. The blue scatterplots are the kinetic energy over the two oscillations and resemble downward-facing parabolas. The grey dots represent the total mechanical energy. The black dotted line is the fit line for the total mechanical energy data and is of the form y=aebx where a=0.0467 and b=-0.067. To decrease the systems amplitude of oscillation by e the energy must decrease by a factor of e2, which would take -2/b seconds. Therefore, it would take 30 seconds to decrease the oscillation amplitude by a factor of e.

**Presentation Mini-Report:**

Breakdown of Energy Conservation and Loss for Non-Ideal Harmonic Oscillations

C. Oliveira1

In this experiment the non-ideal relationships between the kinetic, potential and total energies by analyzing the motion of half of an oscillation of a metal comb attached to a glider on a nearly-lossless air track that was bound by a spring on each end. A photogate aimed at the comb’s teeth as it moved quantified this motion. Several masses were suspended from a pulley connected to the system in order to calculate the spring constant, k, which was found to be 5.83 ± 0.2 N/m. Then, the comb was pulled just left of the left-most comb tooth and released. The breakdown of energy between potential and kinetic energies of this motion was plotted, and a gradual decrease in overall mechanical energy of the system over time was shown. This loss was attributed to dissipative forces, likely forces of friction. The coefficient of friction of the glider was calculated to be 0.0002 ± .001.

Word Count: 153

1*Department of Electrical and Computer Engineering, University of California Los Angeles*

Bibliography:

1. Campbell, W. C. *et al*. Physics 4AL: Mechanics Lab Manual (ver. August 31, 2017). (Univ. California Los Angeles, Los Angeles, California).