Experiment 3: Conservation of Mechanical Energy

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2. Discussion

In my experiment, the photogate is aligned at the right edge of the 32nd tooth from the right at the equilibrium position of the glider. The glider is then pulled to the left so that the photogate sensor is slightly to the right of the right edge of the 1st tooth on the right. The glider is then released.

With the above set up, at the first block time, the glider is 31 teeth and 31 slots away from the equilibrium point. We mark the first block time as t_1, the first recorded position as x_1. Since the photogate sensor only record when it turns from unblocked to blocked, the displacement of the glider is the length of one tooth and one slot between two timestamps. We can come up with the following formula:

$$x_n = x_1 + 0.004(n - 1)$$

where x_n is the displacement at t_n and t_n is the time recorded at the nth block event.

We can then find the average velocity and average displacement between t_n and $t_{n+1}$with equation 3.3 and 3.4 in the lab manual:

$$v(\bar{x}(n)) = \frac{\Delta x}{\Delta t} = \frac{x_{n+1} - x_n}{t_{n+1} - t_n}$$

$$\bar{x}(n) = \frac{x_{n+1} + x_n}{2}$$

The kinetic energy and potential energy at $\bar{x}(n)$ can therefore be calculated:

$$K(\bar{x}(n)) = \frac{1}{2} M (\frac{x_{n+1} - x_n}{t_{n+1} - t_n})^2$$

$$P(\bar{x}(n)) = \frac{1}{2} k \, (\frac{x_{n+1} + x_n}{2})^2$$

Where M is the mass of the glider with the photogate comb, and k is the spring constant.

3. Plots and Tables

My measured value for the mass of the glider with its photogate comb is:

$$M = 0.22500 \pm 0.00005kg$$

Here is the table of data I used to calculate the spring constant k:

Hanging Mass, m(kg) δm = 0.00005kg	Force Applied, F(N) δF = 0.0005N	Position of the glider, l(m) δl = 0.0005m	Displacement of the glider, x(m) δx = 0.0007m
0.00000	0.0000	1.5770	0.0000
0.01860	0.1823	1.6070	0.0300
0.03600	0.3528	1.6320	0.0550
0.05460	0.5351	1.6620	0.0850
0.10000	0.9800	1.7300	0.1530
0.11860	1.1623	1.7530	0.1760

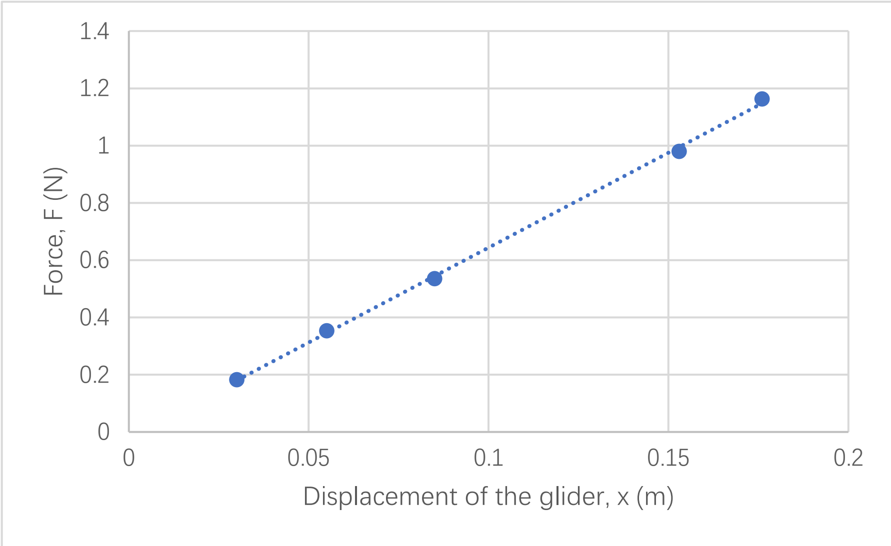

Figure 1. Determining spring constant k. The data points represent the displacement of the glider when different forces are applied. The linear fit curve is F=kx, where $k = 6.6 \pm 0.1$N/m. The linear fit shows that the system has a constant spring constant.

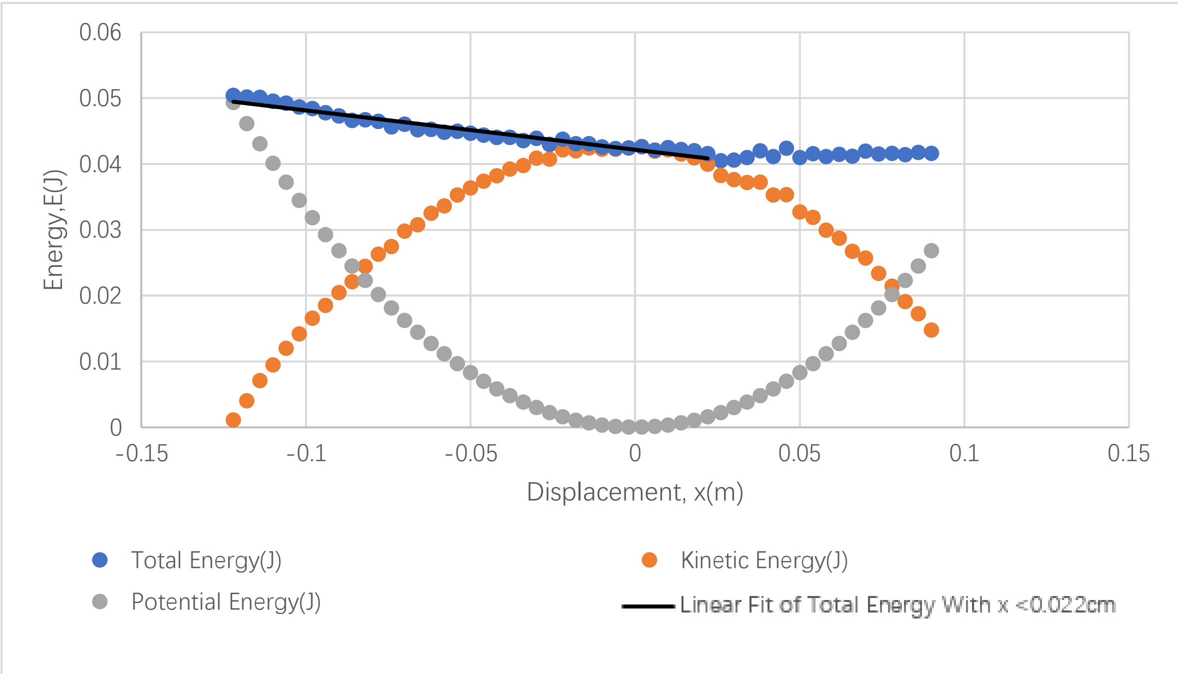

Figure 2. Verifying conservation of mechanical energy using a glider attached to springs. The grey dots represent the potential energy at different positions, the orange dots represent the kinetic energy at different positions. The blue dots represent the total energy at different positions. The first three fourths of the total energy dots show decreasing trend due to small friction on the track. The last one fourth of the total energy dots stop decreasing, which is possibly due to the increasing gravitational energy introduced by the unlevel airtrack. Thus, only the previous part of the total energy data is used for linear fit, which has equation $E=-fx+E_0$, where $f = 0.060 \pm 0.002$N.

The slope of the best fit line is the energy lost per meter moved. Since friction is the only source of energy lost in our system, the absolute value of the slope is the friction of the airtrack.

As the glider is moving throughout the experiment, the friction is kinetic friction. It is given by the following formula:

$$f_k = \mu_k N$$

In our experiment, since the airtrack is almost leveled, we may assume that the normal force is equal to the gravitational force acting on the glider.

$$f_k = \mu_k M g$$

Thus, the coefficient of kinetic friction is:

$$\mu_k = \frac{f_k}{Mg}$$

Take g=9.81kg/s^2, we get:

$$\mu_{k\ best} = \frac{0.060}{0.22500 \times 9.81} = 0.0272$$

$$\delta\mu_k = \sqrt{(\frac{1}{Mg}\delta f_k)^2 + (-\frac{f_k}{M^2 g}\delta M)^2} = 0.0009$$

$$\mu_k = 0.0272 \pm 0.0009$$

Mini-Report

Verification of conservation of mechanical energy using a system consisted of a glider and springs

D. Liu[1]

To verify the principle of conservation of mechanical energy, we set up a system of a glider with a photogate comb on top and each end attached to a spring. The other two ends of the springs are fixed on a leveled airtrack, on which the glider is set to oscillate. A photogate is used to record the position of the glider at different times, with which we calculated the potential, kinetical and total mechanical energy of the system at different positions. By comparing the three energies we found that the mechanical energy of our system is not conserved due to friction, which verifies the principle of conservation of mechanical energy. The friction coefficient is found by investigating the rate of mechanical energy lost.

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