Physics 122 - Lab 6

Goals  To understand work done by conservative and non-conservative forces. To understand conservation of energy. To understand springs.

Equipment  Spring, string, cart and track, motion detector. For this lab, ignore the car’s wheels. Assume that the bottom of the car slides on the top of the track. Let’s pretend that the wheels just make the interface between the car and track frictionless. We’ll be able to adjust the friction of this interface by adjusting the ‘friction screw’ of the cart in part (5) of the procedure. For parts (1) through (4), make sure that the ‘friction screw’ is ‘unscrewed’.

Procedure
1. First measure the end-to-end length, \( L \), of your track. Measure the end-to-end length of the spring, including the ‘attachment loops’. Now choose a length, \( l \), of string with loops tied in each end. Measure the end-to-end distance of the loops. Determine the mass of the cart using the balance.

2. With the track horizontal, secure the spring to the pin at the end of the track nearest the motion detector using the paper clip. Attach one of the loops in the string to the free end of the spring and attach the other loop to the friction screw on the cart. Ask the instructor or TA to inspect your setup. Confirm that you will be able to reliably measure the distance from the motion detector to the reflector attached to the cart by translating the cart by hand along the track. The goal is to aim the motion detector once and then to keep its configuration constant for the rest of the lab. We will now measure the position of the cart while it is at rest by averaging position vs. time data using the motion detector and by noting the scale reading of the front (end attached to the spring) of the cart for the following configurations: (a) string at ‘zero length’ and spring unstretched; (b) string at maximum length and spring unstretched. Perform these measurements at least twice to make sure the results are consistent since all of the analysis depends on their accuracy.

3. Now we will determine the elastic properties of the spring. Be very careful when moving the track. To obtain consistent data throughout the lab, the motion detector should not move relative to the track. We will raise the end of the track with the motion detector a distance \( h \) off of the table top. By knowing \( h \) and \( L \) you can find \( \theta \), the angle the track is inclined from horizontal. Start off with a small \( h \) and increase it until \( \theta \) is about 15° where we’ll leave it for the rest of the lab. For each value of \( h \), record the position of the cart while it is at rest in equilibrium by averaging position vs. time data using the motion detector and by recording the scale reading of the front of the cart. Perform these measurements for at least 5 values of \( h \), increasing \( h \) until \( \theta \sim 15° \).

4. Now we will acquire data that will allow us to investigate energy conservation. With the track at the largest \( h \) from procedure (3), position the cart so that the string is at ‘zero length’ and the spring is unstretched. After the motion detector has been acquiring position vs. time data for about a second, release the cart from rest. Both the position vs. time and velocity vs. time curves should look like smooth sine waves with decreasing amplitude once the cart is ‘bouncing’ on the spring. If there are any discontinuities in the curves, alert the instructor or TA.

5. Repeat (4) for several (3) different settings of the friction screw on the cart.
Analysis (Some of this analysis is best accomplished before you leave the lab!)
1. Using the data acquired in (3), make a plot of the $mgs(\theta)$ vs. how much the spring is stretched. Find the equation of the line that fits the data. What does the slope of this plot represent? Does the plot pass through the point (0,0)? It is very important that you understand the answer to the second question.
2. Using the position and velocity data acquired in (4) and (5), plot the kinetic energy ($K$), gravitational potential energy ($U_g$), elastic potential energy ($U_e$) and total mechanical energy of the system as functions of time and distance traveled. What equations did you use for $U_g$ and $U_e$?

Questions
1. How would friction influence your determination of the spring constant?
2. Interpret the answer to the second question posed in analysis (1) in terms of a ‘physical length’ of the relaxed spring and an ‘elastic length’ of the relaxed spring.
3. How much work against frictional forces does the cart do for each experiment in (4) & (5)? Use this result to determine the coefficient of kinetic friction between the car and track for each experiment.
4. Can you use the final position of the cart to determine the coefficient of static friction? Why or why not?

What you need to turn in
1. The plot you used to determine the spring constant with the value for the spring constant on the graph.
2. The energy plots you made in (2) of the analysis.
3. A paragraph describing the energy plots you made in (2) of the analysis.
4. The answers to the questions, including those posed in the ‘analysis’.

Including the plots and the lab report cover page, your lab report should not be longer than 5 pages.