Lab #8
Conservation of Energy

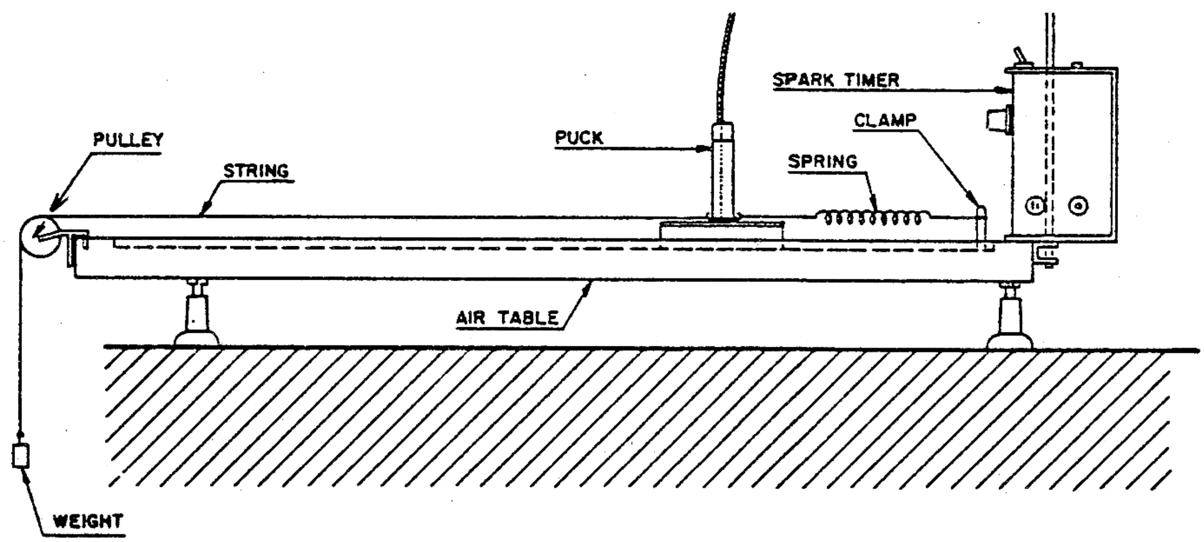
1. Objectives

To examine the principle of conservation of energy for a one-dimensional mass-spring system on a frictionless surface by making independent measurements of the kinetic energy and potential energy.

2. Equipment

- air table
- heavy steel puck
- light string
- pulley
- spring
- various weights

3. Set-up



4. Procedure

1) ***Preliminary adjustments.*** Put a sheet of paper on the air table and level the table before proceeding. Weigh the puck on the balance, adjust the spark-timer interval to 40 ms (25 Hz) and set up the apparatus as shown in the diagram above.
2) ***Determine the spring constant.*** With no weights attached, mark the $x = 0$ position of the puck with a burst of sparks. Attach a 50 g mass to the string passing over the pulley and mark the new position of the puck (with a spark-burst). Repeat for masses of 100, 150, 200, and 250 g. When you have finished, turn the paper over and label the spark-burst according to the masses used.

3) ***Obtain a spark-track of the puck in motion.*** Remove any weights from the string and put the paper back on the table. Mark the $x = 0$ point again, and pull the puck out (almost) to the edge of the table, then with the spark-timer operating, release the puck from this location so that it accelerates back toward the equilibrium position. Stop the spark-timer just as it reaches the equilibrium position.

5. Analysis (in your logbook)

1) Calculate the spring constant of the spring, including uncertainties, using the data obtained in part 1 of the procedure.
2) make a table of position of the puck as a function of time, and use these to calculate values for speed at each time. From these you can then find the squares of the position and speed values (x^2 and v^2), the kinetic and potential energies ($K = ½ mv^2$ and $U = ½ kx^2$), and the mechanical energy ($E = K + U$) of the system. Make an 8-column table showing all of these quantities.

    NOTE: the calculation of speed using the staggered-midpoint-method, is only exact when the acceleration is constant, which is not the case here. But the error in this case is a small fraction of 1%, so we can use it here as well as it will not be significant.

3) Plot graphs of K, U and E as a function of time. For each graph, explain if and how they are consistent with the principle of conservation of energy.
4) What does the value $\frac{1}{2}kx_{\max}^2$ represents?
5) The spring constant was calculated above from the static force data. It can also be found in a completely different way using motion data if the mass of the puck is known. Start with the relation

$$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kx_{\max}^2$$

    and simplify it to get a relation for v^2 in terms of x^2, and explain why a graph of v^2 vs x^2 should be a straight line. Plot such a graph, and calculate from its slope the spring constant, including uncertainties. Compare this value to the one calculated earlier.