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PHYS 231 Lab Exercise: Conservation of Energy

Objective: The law of conservation of energy is one of the most powerful concepts in physics. We will scrutinize this law today by storing potential energy in a rubber band and then converting it into kinetic energy of an air-track glider. By investigating the results, we hope to gain a better understanding of the concepts of *work, energy,* and *conservation of energy.*

Introduction: The concepts of *Work* and *Energy* are crucial for understanding nature. Their importance is not limited to the mechanics of a single object. This concept can equally be applied to complex system – atoms, molecules, and even organisms. Almost acts of motion, transformation, and creation in our worlds are due to *work* being performed and *energy* being transferred.

One special property of *energy* is enshrined in the *Law of Conservation of Energy* that states that the total amount of *energy* in the universe is constant. That is, ***energy* can neither be created nor destroyed; it can only be transformed from one form into another.**

For any mechanical system involving only conservative forces, its total mechanical energy E remains constant. Therefore, the mechanical energy E can be written as:

$$E = K + U \qquad [1]$$

where K is the kinetic energy of the system and U is the potential energy.

Work done by conservative forces exerted by some object onto the system does not change the mechanical energy. However, such work could (and does) bring about transformations between potential and kinetic forms of energy.

Here we study an example of such an energy transformation by storing elastic potential energy in a rubber band and converting it into the kinetic energy of an air track glider. We will use gravity to stretch a rubber band. The force on the rubber band is equal to the tension on the string, T_S, holding the weight mg (see figure below). An ideal rubber band (**Note:** Make sure you have "fresh" rubber bands) obeys Hooke's Law:

$$F = -kx \qquad [2]$$

where k is the spring constant and x is the change in length (from equilibrium) of the rubber band. The elastic potential energy of something obeying Hooke's Law is:

$$U = \frac{1}{2}kx^2 \qquad [3]$$

This potential energy can be converted into kinetic energy of the glider:

$$K = \frac{1}{2}mv^2 \qquad [4]$$

where m is the mass of the glider and v is its velocity. Neglecting all non-conservative forces (like friction) we would expect that $U = K$.

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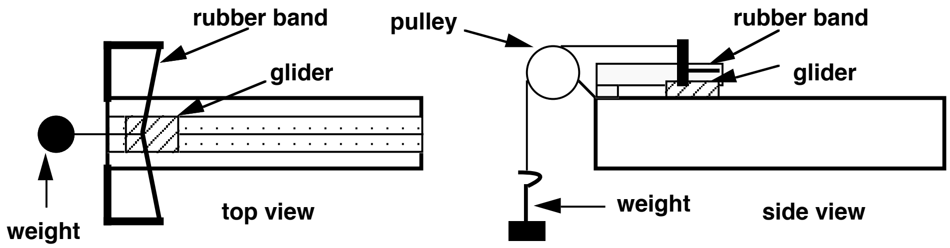
Procedure: The apparatus you will use is the air track, a glider and weights (shown below). Recall that the air track is designed such that frictional forces are negligible. When the weight is released from the rubber band, the potential energy stored in the rubber band is converted to kinetic energy of the glider.



a) Weigh the glider and **record its mass**. m=_____________ (units?) Insert the glider **CAREFULLY** into the trough. (The trough has been precisely machined inside, and dents or scratches impair its function.) Level the trough. The slope of the track may be changed by turning a large screw at its right end. Turn the air on until the glider moves freely along the track. The track is level when a glider released from rest at the center of the track does not move toward either end. Attach a strip of spark tape to the side of the air track.

b) Turn off the air and place the glider so it is just touching but not stretching the rubber band. Turn on the spark timer momentarily to mark this position. This is the equilibrium position of the rubber band (x=0). Write "0" on your tape next to this mark.

c) Tie one end of the thread to the glider and the other to a 5 g mass hanger and place the string over the pulley so the mass pulls on the glider. Turn on the air. Mark the new position of the glider with a spark and label this mark "5". Continue to add mass 5 g at a time, each time marking with a spark the position of the glider and labeling the marks until there is a total mass of 60 g on the hanger.

d) Release the glider by burning the thread between the glider and the pulley with a match. Once the glider has cleared your original marks, turn on the spark timer to record the position of the glider every 0.1s as it moves down the track.

e) Using *Excel*, plot mg vs x for the stretch of the rubber band (**Note:** mg should be the vertical axis and x should be the horizontal). To calculate the work done on the rubber band (equal to the potential energy stored in the rubber band), first determine the effective spring constant for your rubber band by fitting and displaying a straight line to your plot. The slope of this line is equal to k the spring constant. **Include a copy of this plot in your report**. Calculate the potential energy stored in the rubber band from the elastic potential energy equation where x is the maximum distance the rubber band is stretched from equilibrium.

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Record your spring constant here: k =_____________ (units?)

Record the work done here: W=_______________(units)

f) From the spark tape determine the velocity of the glider after it was launched by measuring the distance x required for the glider to move n spark intervals, each of which is 0.1s ($v = \frac{x}{nt}$). Use this velocity to determine the kinetic energy of the glider. Why will the velocity be constant?

Record your velocity here: v=_________________ (units?)

Record your kinetic energy here: K=__________________(units?)

<u>Discussion:</u> Please answer the following questions:

a) Does the potential energy stored in the rubber band equal the kinetic energy of the glider? ___________

b) Calculate a difference between these two energies: ______________

c) Comment on any loss or gain in energy. If energy is lost where do you think it went?

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