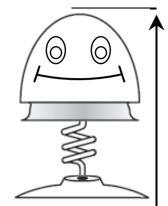
AP Physics Lab 6B: Conservation of Energy & Hooke's Law (Big Idea 4)



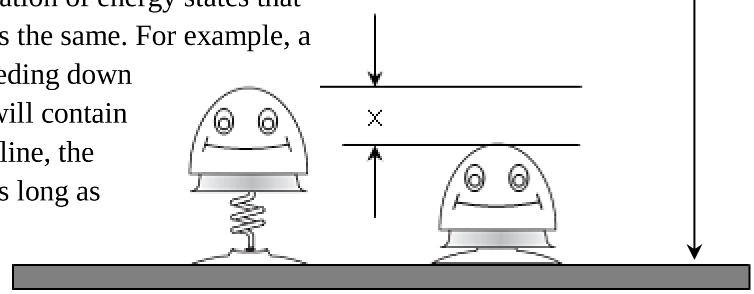
4.C.1.1: The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.

4.C.1.2: The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.

4.C.2.1: The student is able to make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass.

4.C.2.2: The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system.

Background: The objective of this short investigation is to observe the energy transitions in a pop-up toy and to determine the force constant of a spring. Conservation of energy states that energy can change from one form to another, but it is always the same. For example, a roller coaster contains mostly potential energy before proceeding down a hill. However, when at the bottom of the hill, the coaster will contain only kinetic energy. Anywhere along its travel down the incline, the total energy of the system (PE + KE) will remain constant as long as we ignore friction. Total Energy = KE + PE = constant.



When a spring is compressed or stretched from its relaxed position, it's potential energy is determined by $PE_s = ½ kx^2$.where k is the force constant in N/m and x is the displacement from equilibrium. When a spring is compressed, its stored energy can be converted to kinetic energy KE, which in turn can be converted into gravitational potential energy.

Q1. Design and carry out an experiment to determine the following: jump height (H_{max}), gravitational potential energy (ΔPE), initial velocity of the toy (V_o), the spring constant (k) from the height. As always, conduct repeated trials to ensure accuracy, organize your data in a table, and show all calculations.

Q2. If you have not already done so, draw FBDs for the toy for the following scenarios: uncompressed, compressed, midway to maximum height, and maximum height.

Q3. Measure the spring constant using a digital force sensor. Create a graph of the force applied as a function of the displacement of the spring. Explain the significance of the slope.

Q4. Using your graph in Q3, determine the work done when compressing the spring toy.

Q5. Using only energy variables for this lab, derive an expression for the maximum height *h* in terms of *m*, *x*, *k*, and fundamental constants.

Q6. Derive an expression showing that work is equal to the change in kinetic energy. To begin your derivation, you should start with the equations for both work and kinetic energy.

Please asses your lab using the rubric/checklist