Experiment 8: Mechanical Energy

In this lab we will study and investigate the concepts of potential energy, kinetic energy, conservative forces and the conservation of energy in more detail. Potential energy is energy that is associated with and attributed to the configuration, position and arrangement of particles within an object that experiences a conservative force $F(x)$. A conservative force is a force that does zero work on a closed path. That is, the work done by conservative force in going from point A to point B is *independent* of the path from A to B. Examples of conservative forces include gravity and the spring force. When a conservative force does work W on an object, the change in the potential energy ΔU is

$$\Delta U = -W \tag{1}$$

If an object moves from x_0 to x_f, the change in potential energy is

$$\Delta U = -\int_{x_0}^{x_f} F(x)dx \tag{2}$$

For a spring we can use Hooke's law, $F = -kx$, to obtain its potential energy from Equation 1:

$$U = \frac{1}{2}kx^2 \tag{3}$$

where k is the spring constant and x is the displacement of the spring from its rest state. Gravitational potential energy of an object of mass m at a height y is treated in the same manner by noting the force is $F = mg$ and thus resulting in

$$U = mgy \tag{4}$$

Here the potential energy is chosen to be zero at height y=0.

Experimental Methods and Objectives

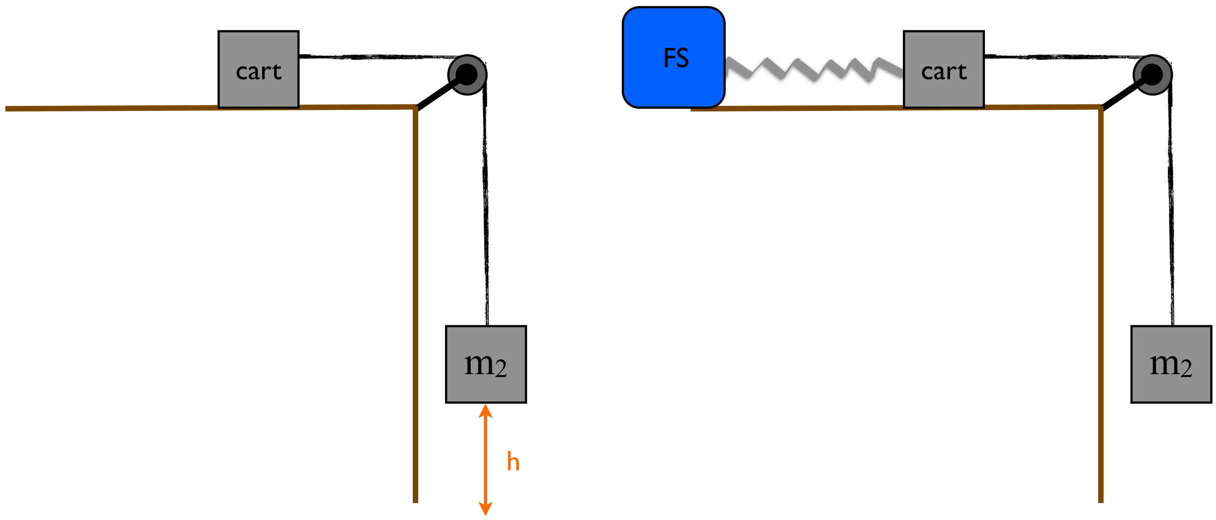
Part 1: In this experiment you are given a frictionless horizontal airtrack, a glider, a hanging-mass with additional masses to add on, a spring, string and a ruler. You can take measurements of the velocity and force actin on the spring using the *photogate* and *force sensor*, respectively. We will start with a glider cart connected by string to the hanging mass over a pulley, as shown in Figure 1a.

Considering vertical positions and speeds at two different times, we can write down the conservation of the energy for the cart and hanging mass system as

$$\frac{1}{2}m_1v_i^2 + \frac{1}{2}m_2v_i^2 + m_2gy_i = \frac{1}{2}m_1v_f^2 + \frac{1}{2}m_2v_f^2 + m_2gy_f \tag{5}$$

where m_1 is the mass of the cart, m_2 is the mass of the hanging weight, and v_i and v_f are their respective initial and final velocities. After releasing the hanging mass, it will fall from the initial height of y_i to y_f. We will assume that the string connecting the hanging mass to the gliding cart is inextensible and has uniform tension, that is, if the cart moves a distance Δx then the hanging weight will fall the same amount Δy ($\Delta x = -\Delta y$). The velocity of the cart can be measured by the photogate sensor (does the hanging mass have the same velocity?). This velocity can be verified by using Equation 5.

- Devise an experimental procedure to test the Conservation of Energy theorem using the above setup (Figure 1). Show that the work done by the falling mass is independent of the path taken.



(a) (b)

Figure 1: (a) Arrangement for Part 1. The hanging mass is initially a height h off the floor. (b) Set up for Part 2. Here a spring is attached to the glider. The force on the spring can be measured with the force sensor (FS).

Part 2: A spring will now be added to the setup as shown in Figure 1b. Assuming the string to be inextensible, as before, the spring stretches the same length as the falling mass.

- Devise an experimental procedure to calculate the total mechanical energy of this spring-cart system and show whether or not the energy is conserved. What does the addition of a spring do to the overall system? Don't forget to measure the spring constant.

A full lab report is not necessary for this lab. Answer the questions on the following page and turn it in with your signed datasheet.

<u>PHYS 123, Lab 8 Questions</u>

Name: **CWID:**

Write your answers on a separate sheet and attach your signed datasheet when turning it in. You must show all of your work for full credit. Make it clear to me you understand what you're doing. Any graphs or tables should be made via computer software and attached to this worksheet.

1. Answer the following questions using the data you acquired in this experiment:

   (a) For the first experiment, explain why work done by the falling mass is independent of the path taken.

   (b) What did the addition of a spring do to the overall system? Is this spring force a conservative force?

   (c) Write down the energy equation relations for the second experiment.

   (d) Where does the maximum kinetic energy in parts 1 and 2 occur?

   (e) Can we truly ignore friction in this lab? Explain using your data.

   (f) Calculate the ratio of the kinetic and potential energies for parts 1 and 2. What do these ratios tell you about the conservation of energy?

   (g) What effect would the release point have on the final velocity?