Work, Kinetic Energy and Conservation of Energy

Introduction

In this lab you will investigate some of the relationships between work and energy. They involve the following concepts: definition of work, relationship of change in kinetic energy to work, gravitational potential energy, and conservation of mechanical energy.

We will use the same "simple" mechanical system which was used in the Newton's Law lab. Recall, a string is attached to a car of mass, m_1, which is on a horizontal frictionless surface. The string (assumed massless) passes over a light pulley (assumed massless and frictionless) and the other end is attached to a hanging mass, m_2. Two photogates are arranged so that after the car is released, the flag on top of the car will pass through each gate before the hanging mass hits the floor. The computer will record the time the flag interrupts the infrared beam at each photogate. If the length of the flag, L, is known, you can compute the speed, $v = L/t$, for the car as it passes the location of each photogate.

First, you will compare the work done **on the car** to the change in the kinetic energy **of the car** as it moves the distance from one gate to the next. Secondly, you will look at the **system** of the **car + hanging mass**. For this **system**, the only external force doing any work is gravity and so for this system the mechanical energy (potential energy + kinetic energy) should be conserved. If that is the case then as the system moves such that the car goes from one gate to the next, any increase in kinetic energy of the **car-hanging mass system** should equal the decrease in the potential energy of the **car-hanging mass system.** Note that you will be able to use the same data for both the first and the second analysis.

Procedure:

Preliminary:

1. The work on the car will be done by the force of the string (the tension). Derive an expression for the tension in terms of the car and hanging masses. (Hint: Do freebody diagrams of the forces on the car and the hanging mass, apply Newton's 2^{nd} Law as you did for the Newton's Law lab. This time eliminate the common acceleration and solve for the tension.)

2. Make sure the interface box (switch in the back) is turned on as well as the computer and monitor. Open Data Studio and select Create Experiment. In the software attach a photogate to each digital port by clicking on each port and selecting a photogate from the list (look at the physical interface box to see where the digital ports are). Once this is done there will be two photogate icons.

3. As in the Newton's Law Lab, measure the length of the flag on top of the car (with its uncertainty), double click on **each photogate icon**, and enter the length of your flag as the "object length". You need not enter any value in the "Space between Gates" box. In the Measurement tab make sure that the Velocity and Time in Gate CH1 and Velcity and Time in Gate CH2 are selected for the first and second photogates respectively.

4. Create a table by double clicking on the table icon in the Displays menu. Drag the data (times and velocities for both Gate 1 and 2).

5. Check the levelness of the track by sending the car back and forth through the photogates and monitoring the times.

Data Collection:

1. Use a hanging mass of 50g.

2. Position the car so the front edge of the flag on the car is about 10 cm from the first gate.

3. Click Start, release the car, then click Stop.

4. Repeat, but this time start the car with the flag about 20 cm from the first gate.

5. Copy the data (v through each gate) for your two runs below.

Analysis:

1. Determine the uncertainty in the velocity and velocity squared values.

2. For each of your two runs, calculate independently the work done **on the CAR** and the change in kinetic energy **of the CAR**. Reminder, the force on the car is the tension in the string (which you will need to calculate) and the distance the force acts is the distance between the gates (which you will need to measure). Remember to incorporate the uncertainties.

3. How do your results in (2.) compare with what is expected by theory?

4. How did the change in kinetic energy of the car compare for the two different runs? Explain the result.

5. For one of your runs, compare the change in kinetic energy of the **car-hanging mass SYSTEM** to the change in the potential energy of the **car-hanging mass SYSTEM**. Remember to incorporate the uncertainties. Does this agree with what you would expect if mechanical energy is conserved?

6. You have ignored friction in your analysis. If there is indeed some small friction in the air track, what effect would that have on your results and your comparison with theory? Be as specific as possible.

7. What other assumptions have you made? How might they affect your results and your comparison with theory?

Above and beyond experimentation:

1. In the front of the room is a Hot Wheels track with a loop de loop. Predict the height from which you will need to release the car so that it will successfully complete the track.

2. Perform the experiment. Was it as you predicted? If not explain the source of the discrepancy.