Work and Energy

We're going to use the same apparatus that we used in last week's "Newton's Laws" lab. A string is attached to a car of mass m_1 which is on a horizontal frictionless surface. The string passes over a pulley, 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 amount of time the flag interrupts the infrared beam at each photogate. If the length L of the flag is known, we can compute the average speed $v = L/t$ for the car as it passes the location of each photogate.

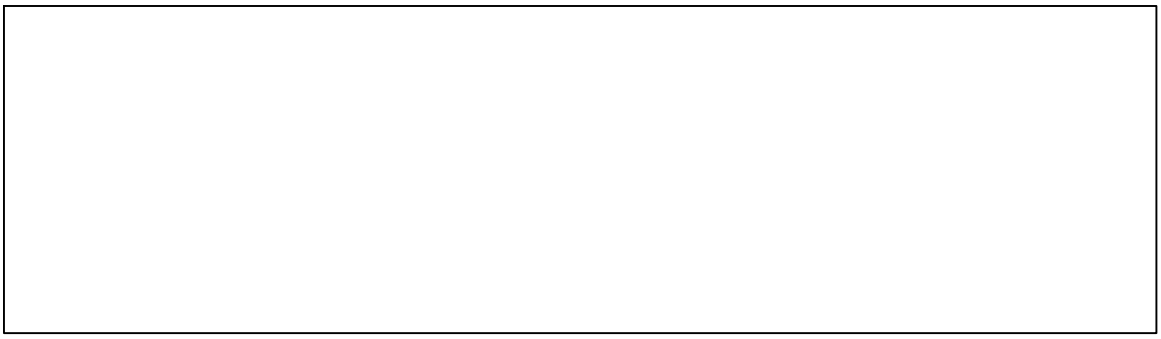
Analysis 1: One way to analyze this situation is to look only at the motion of the car. The tension force from the string does work on the car to increase its kinetic energy. In Problem 47 of the homework from chapter 4, we obtained the result that the tension force is given by

$$F_T = \frac{m_1 m_2 g}{m_1 + m_2}.$$

In the first investigation, you will compare the work done by the tension force to the measured change in kinetic energy.

Analysis 2: An alternate approach to analyzing the problem is to treat the car and the hanging mass as a single system in which mechanical energy is (approximately) conserved. Since the hanging mass falls, the gravitational potential energy of the system decreases. Since the car and the hanging mass are speeding up, the kinetic energy of the system increases. In the second investigation, you will see if mechanical energy is conserved in this system.

1. Measure the length of the flag on top of the car (with its uncertainty), the distance between the photogates (with its uncertainty), and the mass of the car. We will treat the masses in this lab as exact. You will use 50g as the hanging mass.



2. Turn on the interface box, if it's not already on. Open Science Workshop. Click on File on the top menu bar, click on Open and select the folder PHY151. Open file Workeng2.

3. Below the picture of the interface box, there is a drawing of two photogates. Double click on it. In the dialog box that pops up, enter the length of your flag as the "object length". Do NOT enter any value in the "Space between Gates" box. Then click on the OK button.

4. Clean up your display area by shrinking the main window so that it shows only the REC, MON, STOP, PAUSE button area.

5. Trial A: Position the car so the front edge of the flag on the car is about 10 cm from the first gate.

6. Click on the REC button and release the car. Click on the STOP button after the car has passed through both gates. Record the amount of time the car spent in each gate.

Trial A:	
Time in gate 1 =	Time in gate 2 =

7. Repeat, but this time start the car with the flag about 20 cm from the first gate. Again, record the amount of time the car spent in each gate.

Trial B:	
Time in gate 1 =	Time in gate 2 =

8. What is the relative uncertainty in your time measurements?

9. Determine the average velocity of the car in each gate for both trials.

Trial A:	
Velocity in gate 1 =	Velocity in gate 2 =

Trial B:	
Velocity in gate 1 =	Velocity in gate 2 =

10. What is the relative uncertainty of those velocities?

11. Determine the kinetic energy of the car in each gate for both trials.

Trial A:

KE in gate 1 = KE in gate 2 =

Trial B:

KE in gate 1 = KE in gate 2 =

12. What is the relative uncertainty in each of those kinetic energy values?

13. What is the change in kinetic energy for each trial?

Trial A:

ΔKE =

Trial B:

$\Delta KE =$

14. What is the absolute uncertainty in each of these results?

Trial A:

Uncertainty in ΔKE is

Trial B:

Uncertainty in ΔKE is

15. How much work does the tension force do on the car as it travels between photogates? Is the amount of work the same or different for the two trials?

$W =$

16. What is the absolute uncertainty in the work done by the tension force?

Uncertainty in W is

17. Now, at last…for each of the two trials, does the change in kinetic energy equal the work done by the tension force within experimental uncertainty?

Trial A:

Trial B:

Yay!

18. Looking at just *Trial B* now, we're going to begin the second analysis. How much did the kinetic energy of the (car + hanging mass) system change in *Trial B*? What is the uncertainty in that result?

19. How much did the gravitational potential energy of the (car + hanging mass) system change in *Trial B*? What is the uncertainty in that result?

20. Was mechanical energy conserved in this system?