

5. WORK–ENERGY THEOREM

Read Appendix C before coming to the laboratory

OVERVIEW:

This week you will use data from Lab 3: Force and Acceleration to test the Work-Energy Theorem. You'll examine the forces acting on the glider to calculate the net work done on the glider, then use data recorded by the Logger Pro software to determine the kinetic energy of the glider. If the Work-Energy Theorem is valid, the net work done on the glider during any time interval should equal its change in kinetic energy.

LEARNING OBJECTIVES:

- Calculate work done on an object
- Calculate the kinetic energy of an object
- Determine the relationship between the work done and the change in kinetic energy

PROCEDURE:

The Work-Energy Theorem states that the change in kinetic energy of an object is equal to the net work done by all the forces acting on that object. If we correctly account for all the forces acting, therefore, we should be able to test this theorem.

Let's return to the data from Lab 3: Force and Acceleration. You'll need to return to the raw data in order to perform the calculations needed to test the Work-Energy Theorem.

Examine the different trials on the $v(t)$ graph you made. Select the trial whose data have the best linear behavior, and whose fit line passes through the data points as expected. (Consult your instructor if you have any questions about this.) Then, copy the (t,x,v) data, along with the linear regression results, into a new spreadsheet file. For each time, calculate the kinetic energy of the glider + weights. (Be sure to include the mass of the weights that were sitting atop the glider for that run.)

Next, create a new column on your spreadsheet and for each time, calculate the change in kinetic energy from the initial time. This will just require you to subtract the initial kinetic energy from each of your subsequent kinetic energy values.

Next, use Newton's 2nd Law, along with your previous results from this trial, to calculate the net horizontal force acting on the glider and causing it to accelerate.

Now for each time, you need to calculate the accumulated work done on the glider by the net horizontal force. By "accumulated work", we mean the total work done from the initial time up to the present time. Recall that

$$W = \int \vec{F} \cdot d\vec{s} \quad (1)$$

Since the motion of the system is in one dimension, $d\vec{s} = dx\hat{i}$, and the dot product becomes easy to evaluate, as shown in Eq. 2 below:

$$W = \int \vec{F} \cdot d\vec{s} = \int \vec{F} \cdot dx\hat{i} = \int F_x dx \quad (2)$$

If the acceleration of the system is constant, then the net horizontal force F_x is constant, making this integral easy to evaluate. Use the resulting expression to calculate the accumulated work done for each time.

Now, plot the change in kinetic energy versus the accumulated work done. If the plot looks linear, perform a regression analysis of this data. **What value of slope should this plot have? Does it? How about the y-intercept? If the plot indicates a slope or intercept different than what you expected, can you come up with an explanation?**

TURN IT IN:

1. The laboratory report form for this experiment.
2. A copy of your spreadsheet, including the regression output. Make sure the data are clearly labeled and that the calculations are clearly identified on the spreadsheet.
3. Your properly labeled graph with an appropriate title and caption.