

## All Work and No Play Lab

### Teacher's Guide

**Topic:**

Work, Energy and Power

**The following information is provided to the student:**

**Question:**

How does the work done upon a cart compare to the potential energy change of the cart as it is pulled up a hill at a constant speed by a horizontal force?

**Purpose:**

To compare the work done on a cart to the potential energy change of the cart as it is pulled up a hill at a constant speed by a horizontal force.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section should include a table of collected and calculated data (or two tables). Work should be clearly shown for each type of calculation performed. The Conclusion should answer the *question* posed in the Purpose. The Discussion of Results section should logically discuss how the data serve as evidence for the conclusion. An error analysis should be conducted and percent difference calculations should be included; as always, work should be shown for at least one of the calculations.

**Materials Required:**

Slotted wood board; cart; force scale; paper clip; string; meter stick; mass balance.

**Description of Procedure:**

A paper clip is attached to a cart to form a hook. A string is tied to the hook. A slotted wood board is elevated at one end by resting it upon a chair in order to form an inclined plane. The cart is placed upon the inclined plane and the string is passed through the slot. While one student holds the board in place to prevent it from moving, a second student pulls upon the string with a horizontal force in order to pull the cart up the hill at a constant speed. The displacement of the cart from the floor to the seat top (along the inclined plane) is measured. The height of the seat top above the floor is also measured. These two distance measurements are used in a trigonometric function in order to determine the angle of the incline and thus the angle between the force and displacement vector. The work done upon the cart is calculated from the force value, the displacement value, and the angle between the force and displacement vector. A total of three trials are performed for three different incline angles. The mass of the cart is measured and used to calculate the potential energy change in pulling the cart from the floor to the seat top.

**Alternative Materials and Procedure:**

A computer interfaced force probe can be used in place of a force scale. A protractor can be used to measure the angle between the force and the displacement instead of using distance measurements and trigonometry.

**Safety Concern:**

## The Laboratory

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

### Suggestions, Precautions, Notes:

1. A slotted board is simply a wooden board into which has been cut a long, 1-inch wide slot using a reciprocating saw. A string can be attached to a cart and pulled through the slot in order to exert a horizontal pull upon the cart.
2. Emphasize to the students that they are to pull the cart to the same height each time - not to the end of the wooden board. Also emphasize to students that the force should be exerted horizontally.
3. The force that is exerted on the cart can be measured in any equilibrium situation - either by pulling the cart up the inclined plane at a constant speed or by holding the cart at rest.

### Auxiliary Materials:

None

### Scoring Rubric:

<b>E12. All Work and No Play Lab</b>	<b>Score</b>
— Included, labeled and organized all parts of the lab report. — Data section included an organized table of data with column headings and units; all measured data is included in the table and clearly defined. A sample calculation is provided for each type of calculation; work is labeled and clear. Work and $\Delta PE$ values are included in the table. Data are reasonably accurate. — Conclusion answers the <i>question</i> posed in the Purpose; <i>answer</i> is correct and consistent with the Data. — Discussion of Results logically discusses how the data supports the conclusion. An error analysis is included. Percent difference calculations are reported; work is clearly shown and labeled for at least one of the calculations.	—/—

### Connections to The Physics Classroom Tutorial:

The following readings are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/energy/u5l1a.cfm>

<http://www.physicsclassroom.com/Class/energy/u5l2b.cfm>

<http://www.physicsclassroom.com/Class/energy/u5l2bc.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 1, 9 and 10 of the Work and Energy module are suitable accompaniments to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>