13 Work, Power, and Energy

Name________________________________

Lab A: WORKING WITH AN INCLINED PLANE

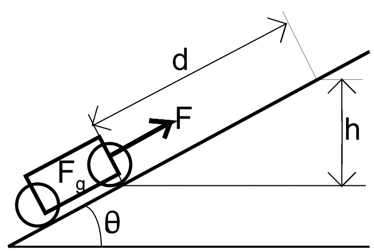
AP Physics B

An inclined plane is a simple machine used to lift objects by moving them diagonally rather than lifting them straight up. The inclined plane allows you to exert less force in raising an object to a certain height than would be needed to directly lift the object. In using an inclined plane, however, there is a trade-off, just as there is in using any type of simple machine. In this lab you will examine the use of an inclined plane and identify the trade-off in using it. This lab will help you understand an important concept in physics about force and distance.

EXPLORATION

You will be pulling a "Hall's carriage" up an adjustable inclined plane. A Hall's carriage is a 4-wheeled cart that can hold various weights and, more importantly, is designed to have very low friction both internally and with the surface it rolls over. Thus, we can safely ignore frictional effects in this lab if you ensure that the wheels of the carriage turn properly.

The diagram shows the variables associated with an inclined plane. Those are the variables with which you will experiment.



θ = angle of the plane to the horizontal
h = height carriage is moved through
d = parallel displacement of the carriage
F_g = load moved up the plane
F = force exerted up the plane

PROCEDURE

First set the angle, θ, on the inclined plane. Record that value in the table. Do not change that angle during each series of measurements. Weigh the carriage and record this ***unloaded*** weight in the space above the table.

Measure a displacement **d** along the plane through which you can pull the cart with constant velocity. Noting the precise displacement **d** along the plane the carriage will be pulled over, use the trigonometric formula $\mathbf{h = d \sin \theta}$ to calculate **h**. Record **d** and **h** in the table.

Place the 500 gram mass in the carriage. Record the ***total*** weight of the ***loaded*** carriage as the first weight $\mathbf{F_g}$ in the table. Now use the spring scale to pull the carriage up the plane. Be sure the force needed to pull the object up the plane, **F**, is exerted **parallel** to the plane. Record **F** in the table.

Now repeat the above procedure with 750 grams in the carriage. Keep the angle, θ, of the plane the same.

Next, replace the 750 grams with a 1000 gram mass and repeat the procedure again.

You have now completed one set of measurements. Change the angle, θ, of the plane and repeat the entire procedure to obtain a complete set of measurements for two different angles.

Carriage's Unloaded Weight = ________ N

θ (°)	F_g (N)	h (m)	F (N)	d (m)	Left Side	Right Side	% diff.

Look at the variables $\mathbf{F_g}$, **h**, **F**, and **d**. These four variables can be related by a mathematical equation. Use the common math operations (addition, subtraction, multiplication, and division) to find the equation.

Now check how well your equation fits the data by calculating out the left side of the equation for each trial in the first shaded column of the table. Then calculate out the right side of the equation in the second shaded column. Finally, calculate the percentage difference between the two sides of your equation in the last shaded column.

$$\%\ \textit{difference} = \frac{\textit{larger} - \textit{smaller}}{\textit{average}} \times 100$$

EXAMPLE: If your equation were $\mathbf{F_g + h = F - d}$, you would calculate $\mathbf{F_g + h}$ for each trial and put the results in the first shaded column. You would then calculate $\mathbf{F - d}$ for each trial and put the results in the second shaded column.

When you have found an equation which yields low percentage differences for all trials, write it in the space below:

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The equation you have written involves forces and displacements. Rearrange your equation, if necessary, so that each side contains a force and a displacement. Write your rearranged equation in the space below (omit if your equation was already in this format):

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In Physics, force and displacement go together in several concepts. You have already explored a concept in which forces and distances are *perpendicular* to each other, that of torque. Torque uses the *cross product* method of vector multiplication, yielding a vector perpendicular to both the force and displacement vectors.

In this lab, the forces and distances involved are *parallel* to each other. This is characteristic of a concept called *work*, and involves the *dot product* method of vector multiplication. Note that work, unlike torque, is a scalar quantity. We will also use a different unit for work than was used for torque.