Name____________________________________ Period_________ Date_________

CONCEPTUAL PHYSICS | **Experiment**

9.1 Energy: Work

AN UPHILL CLIMB

Purpose

In this experiment, you will determine what advantage—if any—there is in using an inclined plane to move an object to a higher elevation.

Required Equipment and Supplies

dynamics cart and track or board that can be inclined and secured at various angles
spring scale (capable of weighing the dynamics cart)
table clamp
support rod
rod clamp
meterstick
protractor

Discussion

Why are ramps used when lifting heavy objects? Does it make the task easier (requiring less force)? Does it make the movement shorter (requiring less distance)? Does it make the effort more efficient (requiring less work)? Perhaps it does several of these; maybe it does none of them. You will learn more from this lab if you record your initial thoughts before making any measurements or calculations.

What advantage or disadvantages are there in using a ramp when lifting a heavy object?

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In this experiment, the cart will act as the heavy object. Your task will be to move your cart a vertical distance of 20 cm above the tabletop. You will arrange a series of ramps (inclined planes) at different angles to accomplish this task. You will measure the force needed to move a cart up the incline. You will also measure the distance through which that force would be applied to finish the job. You will then calculate the work required to lift an object using an inclined plane. By the end of the experiment, you will be able to identify what an inclined plane can do for you in terms of force, distance, and work.

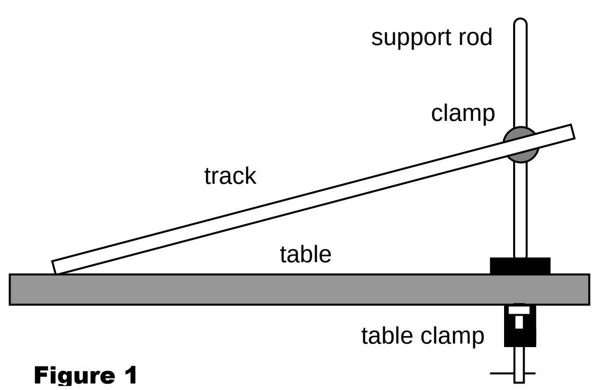

Figure 1

Procedure

Shallow Incline

Step 1: Arrange the apparatus as shown in Figure 1. The plane should be inclined at an angle between 20° and 30°. Check the angle with the protractor as shown in Figure 2.

Step 2: Measure the force needed to pull the cart along this incline using the spring scale as shown in Figure 3. The spring scale is held parallel to the inclined plane when the measurement is made. Since the force needed to move the cart at a constant speed is the same as the force needed to keep the cart at rest on the plane, measure the force when the cart is at rest. Record the force below and transfer the value to the data table.

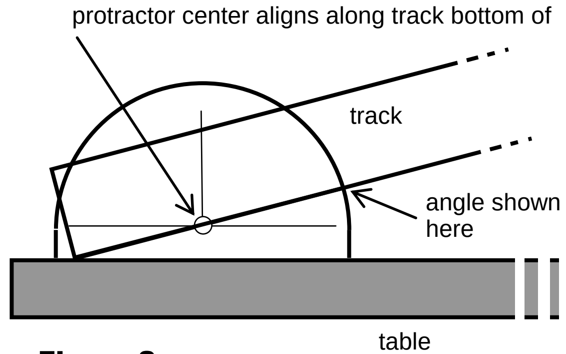

Figure 2

Shallow incline force:

F = ______________________ N

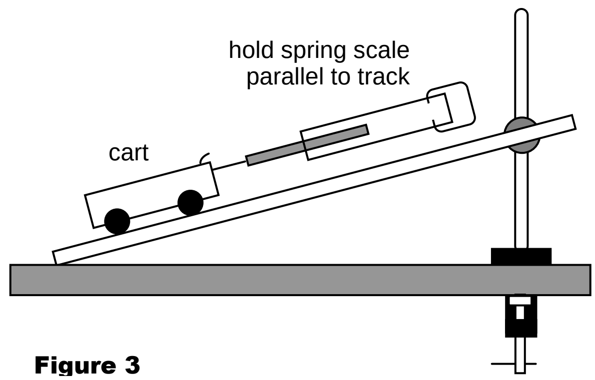

Figure 3

Step 3: Measure the distance the cart would travel along the inclined path to get from the tabletop to a distance 20 cm above the tabletop. See Figure 4. The path starts at the tabletop (even if the object being used as an incline plane doesn't come all the way down to the tabletop). The path ends where the inclined plane is 20 cm above the tabletop. This distance will be greater than 20 cm for all inclined planes (unless the plane goes straight up). Convert the distance from centimeters to meters. Record the distance below and transfer the value (in meters) to the data table.

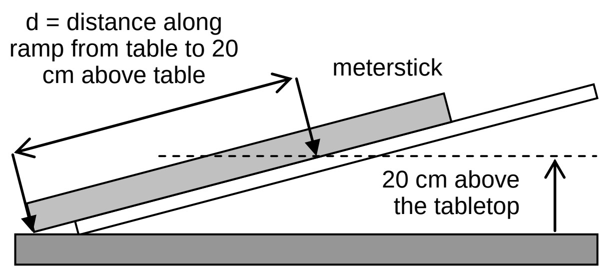

Figure 4

Shallow incline distance:

d = ______________________ cm

= ______________________ m

Medium Incline

Step 4: Increase the angle of incline to a value between 40° and 50°.

Step 5: Measure the force needed to move the cart along this incline and record it on the data table.

Step 6: Measure the distance the cart would travel along this path to get 20 cm above the tabletop. The upper end of the incline is much higher now than it was for the shallow incline, but our only concern is get the cart 20 cm above the tabletop. The distance the cart would travel along this path will be smaller than the distance it would travel along the shallow incline. Record the distance (in meters) on the data table.

Steep Incline
Step 7: Increase the angle of incline to a value between 60° and 70°.

Step 8: Measure the force needed to move the cart along this incline and record it on the data table.

Step 9: Measure the distance the cart would travel along this path to get 20 cm above the tabletop. Record the distance (in meters) on the data table.

Straight Up
Step 10: Measure the force needed to move the cart straight up. No incline is needed for this task. Record the force on the data table.

Step 11: The distance the cart would travel along this path to get 20 cm above the tabletop is 20 cm. Record the distance (in meters) on the data table.

Calculating Work
Step 12: Calculate the work done along the shallow incline. Multiply the force applied to the cart by the distance the cart traveled to get 20 cm above the tabletop. Show the calculation for the shallow path below and transfer the result to your data table. Include the correct units in all your values.

$W = F \cdot d =$ ____________________ x ____________________ = ____________________

Step 13: Calculate the work for the other paths: the medium incline, steep incline, and straight up. Record the results on the data table.

Step 14: Show your instructor your completed data table before proceeding to the Summing Up section.

Data Table

	Angle θ (degrees)	Force F (newtons)	Distance d (meters)	Work W (joules)
Shallow Path				
Medium Path				
Steep Path				
Straight Up				

Summing Up

1. As the incline gets steeper, what happens to the force required to pull the cart?
   ___The force increases significantly.
   ___The force decreases significantly.
   ___The force remains about the same.
   (Compare the force needed to pull the cart along the shallow path to the force needed to pull the cart straight up. A significant difference is one that is 20% or greater.)

2. As the incline gets steeper, what happens to the distance traveled by the cart?
   ___The distance increases significantly.
   ___The distance decreases significantly.
   ___The distance remains about the same.
   (Compare the distance along the shallow path to the distance of the path straight up.)

3. As the incline gets steeper, what happens to the work required to move the cart 20 cm above the tabletop?
   ___The work increases significantly.
   ___The work decreases significantly.
   ___The work remains about the same.
   (Compare the work needed to move the cart up the shallow path to the work needed to move the cart straight up.)

4. What is the **advantage** of using an inclined plane rather than moving something straight up?

5. What is the **disadvantage** of using an inclined plane rather than moving something straight up?

6. The work done to move something is a measure of the energy required to complete the task. The energy required to move an automobile is provided by the fuel. Would it be more fuel-efficient to drive to the top of a hill along a steeply inclined road or a gradually inclined road? Explain your answer in terms of what you observed in this experiment.