Name _____ Class _____ Date _____

Core Skill Lab

Machines and Efficiency

In this experiment, you will raise objects using two different types of machines. You will find the work input and the work output for each machine. The ratio of the useful work output to the work input is called the *efficiency* of the machine. By calculating efficiency, you will be able to compare different machines for different jobs.

OBJECTIVES

Measure the work input and work output of several machines.

Calculate the efficiency of each machine.

Compare machines based on their efficiencies, and determine what factors affect efficiency.

MATERIALS LIST

- balance
- C-clamp
- cord
- dynamics cart
- inclined plane
- mass hanger
- pulleys, single and tandem
- meterstick
- set of hooked masses
- right-angle clamp
- support stand
- suspension clamp

SAFETY 

- Tie back long hair, secure loose clothing, and remove loose jewelry to prevent their getting caught in moving parts and pulleys.
- Attach string to masses and objects securely. Falling or dropped masses can cause serious injury.

Preparation

1. Read the entire lab, and plan what measurements you will take.
2. Record your data in the data table below.

Trial	Machine	$mass_1$ (kg)	Δh (m)	$mass_2$ (kg)	Δd (m)
1					
2					
3					
4					
5					
6					

Procedure

INCLINED PLANE

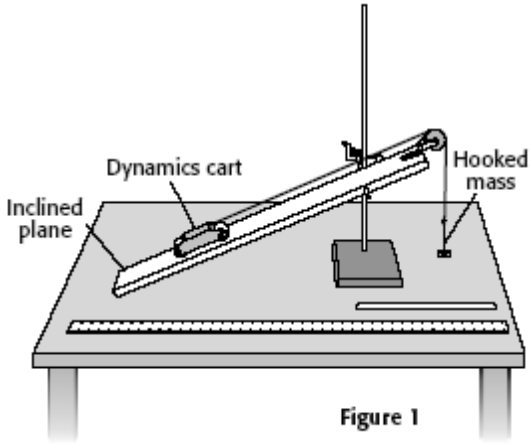

Figure 1

3. Set up the inclined plane as shown in **Figure 1**. Set the incline securely to any angle. Keep the angle constant during this part of the experiment. Place the inclined plane away from the edge of the table, or clamp its base to the edge of the table.

4. Measure the mass of the cart. Attach a piece of cord through the hole on the body of the cart. The cord should be long enough so that the other end of the cord reaches the table top before the cart reaches the top of the incline. Place the cart on the plane and run the cord over the pulley at the top of the plane. Attach a mass hanger to the free end of the cord.

5. Place a 200 g mass in the cart. Record the total mass of the cart and its contents as $mass_1$. Attach masses to the mass hanger until you find the lowest mass that will allow the cart to move up the plane with a constant velocity. Stop the cart before it reaches the top of the incline. Record the mass of the mass hanger plus the added mass as $mass_2$ in your data table.

6. Measure the distances, and record them. Δh is the *vertical* distance the cart moves, while the mass hanger on the cord moves the distance Δd.

7. Repeat steps 5 and 6 several times, increasing the mass in the cart by 100 g and finding the mass that will allow the cart to move with a constant velocity each time. Record all data for each trial in your data table.

PULLEY

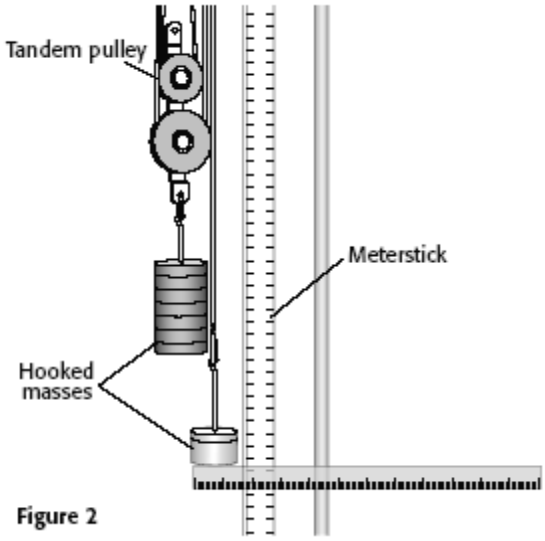

Figure 2

8. Set up a pulley system like the one shown in **Figure 2.** For the first trial, use five pulleys. Keep the area beneath the pulley system clear throughout the experiment. Measure the mass of the bottom set of pulleys before including them in the setup. Attach a 500 g mass to the bottom, as shown. Record the total mass of the 500 g mass plus the bottom set of pulleys as $mass_1$ in your data table.

9. Starting with 50 g, add enough mass to the mass hanger to prevent the pulleys from moving when released. Place the mass hanger just below the 500 g mass, and measure the initial positions of both masses by measuring the height of each mass above the base.

10. Add masses to the mass hanger until you find the mass that will make the 500 g mass move up with constant velocity once it has been started. Record the mass of the mass hanger plus the added mass as $mass_2$ in your data table.

11. Measure the final positions of both masses, and record the distances (final position - initial position) in your data table. Δh is the *vertical* distance through which the mass on the pulley is raised, while the mass on the mass hanger moves down through the distance Δd.

12. Using the same 500 g $mass_1$, perform two more trials using different pulley systems (four pulleys, six pulleys, and so on). Record all data. Be sure to include the mass of the bottom set of pulleys in the total mass that is raised in each trial.

13. Clean up your work area. Put equipment away safely so that it is ready to be used again.

Analysis

1. Organizing Data For each trial, make the following calculations:

a. the weight of the mass being raised

b. the weight of the mass on the string

c. the work input and the work output

2. **Analyzing Results** In which trial did a machine perform the most work? In which trial did a machine perform the least work?

3. **Organizing Data** Calculate the efficiency for each trial.

4. **Analyzing Data** Is the machine that performed the most work also the most efficient? Is the machine that performed the least work also the least efficient? What is the relationship between work and efficiency?

Conclusions

5. **Drawing Conclusions** Based on your calculations in item 4, which is more efficient, a pulley system or an inclined plane?

6. **Evaluating Methods** Why is it important to calculate the work input and the work output from measurements made when the object is moving with constant velocity?

Extensions

7. **Designing Experiments** Design an experiment to measure the efficiency of different lever setups. If there is time and your teacher approves, test your lever setups in the lab. How does the efficiency of a lever compare with the efficiency of the other types of machines you have studied?
8. **Building Models** Compare the trial with the highest efficiency and the trial with the lowest efficiency. Based on their differences, design a more efficient machine than any you built in the lab. If there is time and your teacher approves, test the machine to test whether it is more efficient.