Activity

Model and Invent

Work Smarter

Lab Preview

Directions: *Answer these questions before you begin the Activity.*

1. Give the equation for the IMA of an inclined plane.

2. List several simple machines.

You are the contractor on a one-story building with a large air-conditioner. The lower the force, the easier the job for your crew. What ways can you think of to get the air conditioner to the roof?

Recognize the Problem

How can you minimize the force needed to lift an object? What machines could you use?

Thinking Critically

Is a lever practical for this job? Why? Consider a fixed pulley with ideal mechanical advantage (*IMA)* = 1, a moveable pulley with *IMA* = 2, a block and tackle with one fixed double pulley and one moveable double pulley with *IMA* = 4, and an inclined plane with *IMA* = slope/height = 4. The latter two machines may differ in efficiency. How can you find the efficiency of machines?

Possible Materials

Spring scale, 0–10 N range
9.8 N weight (1 kg mass)
Wooden board, 40 cm long
Support for board, 10 cm high
Two double pulleys
String for pulleys
Stand or support for the pulleys

Goals

- **Model** lifting devices based on a block and tackle and on an inclined plane.
- **Calculate** the output work that will be accomplished.
- **Measure** the force needed by each machine to lift a weight.
- **Calculate** the input work and efficiency for each model machine.
- **Select** the best machine for your job based on force required.

Planning the Model

1. Work in teams of at least two. **Collect** all the needed equipment.
2. Sketch a model for each lifting machine on a separate sheet of paper. **Model** the inclined plane with a board 40 cm long and raised 10 cm at one end. Include a control in which the weight is lifted while being suspended directly from the spring scale.
3. Use the data table in the Data and Observations section to record your information.

Check the Model Plans

1. Is the pulley support high enough that the block and tackle can lift a weight 10 cm?
2. Obtain your teacher's approval of your sketches and data table before proceeding.

Making the Model

1. Tie the weight to the spring scale and measure the force required to lift it. Record the effort force in your data table under control, along with the 10-cm effort distance.
2. Assemble the inclined plane so that the weight may be pulled up the ramp at a constant rate. The 40-cm board should be supported so that one end is 10-cm higher.

Activity (continued)

3. Tie the string to the spring scale and measure the force required to move the weight up the ramp at a constant speed. Record this effort force under inclined plane in your data table. Record 40 cm as the effort distance for the inclined plane.
4. Assemble the block and tackle using one fixed double pulley and one moveable double pulley.
5. Tie the weight to the lower pulley and tie the spring scale to the string at the top of the upper pulley.
6. **Measure** the force required to lift the weight with the block and tackle. Record this effort force.
7. **Measure** the length of string that must be pulled to raise the weight 10 cm. Record this effort distance.

Data and Observations

	Control	Inclined plane	Block and tackle
Ideal Mechanical Advantage (IMA)			
Effort Force, F_e (N)			
Effort Distance, d_e (m)			
Resistance Force, F_r (N)			
Resistance Distance, d_r (m)			
$Work_{in} = F_e \times d_e$, (Joules)			
$Work_{out} = F_r \times d_r$, (Joules)			
% Efficiency, $(Work_{out} / Work_{in}) \times 100$			

Analyzing and Applying Results

1. **Calculate** the output work for all three methods of lifting the 9.8 N weight 10 cm.

2. **Calculate** the input work and the efficiency for the control, the inclined plane, and the block and tackle.

3. Which machine used the lowest force to raise the weight? How do you account for the observed differences in efficiencies? How could you improve the efficiency for each machine?

Communicating Your Data

Make a poster showing how the best machine would be used to lift the air conditioner to the roof of your building.