Physics Name: _____

Activity - *Pulleys*

Problem: To study the pulley as a simple machine and to determine the *efficiency* and *mechanical advantage* of a multiple pulley system.

Discussion: Pulleys are examples of simple machines that make it easier to perform certain tasks. For example, a pulley system can be used to lift heavy objects--like the engine of a car--with a much smaller force than its weight. This is called mechanical advantage. The mechanical advantage of a machine is just the ratio of force you get out to the force you put in.:

M.A. = force out ÷ force in

However, since there are no "freebies" in Physics you can't just gain force from nowhere. Why? You must only gain force at the expense of distance. If you have ever used a pulley system you will recall that you needed less force to lift the object but you had to pull the string a greater distance.
Also, in the real world there is friction, a force that dissipates useful energy into heat. Since some of your energy is lost the work you get out is never quite equal to the work you put in. Scientists and engineers spend a great deal of time trying to reduce the energy lost to friction and other dissipative forces. Give an example of how this is done. The ratio of work out to work in is defined as a machines *efficiency*.

Eff = work out ÷ work in

In this experiment you will build various pulley systems and determine their efficiency and mechanical advantage.

Materials:

Mechanical support arm	1 - triple pulley	mass set/hanger
2 - spring scales	string	
2 - single pulleys	2 meter sticks	

Procedure:

1. Set up a single pulley system. Attach a weight to the load end of the cord. This is the *resistance force* on the pulley. Record this in your data table.
2. Zero the spring scales. Then pull on the hook and measure the force it takes to start the weight moving slowly upward at a **constant speed**. This is sometimes called the *effort force*. Record this in your data table.
3. Pull on the hook and cause the weight to move up slowly some distance. This is called the *resistance distance*. Use a meter stick to measure the distance. Record this in your data table.
4. At the same time that the weight is moving up a distance, measure the distance that you have to pull on the scale--the *effort distance*. Record this in your data table.
5. Set up a double pulley system. Repeat steps #2-#4 with the double pulley system.
6. Set up a triple pulley system. Repeat steps #2-#4 with the triple pulley system.
7. Set up your own pulley system designed to get the maximum possible mechanical advantage. Draw a picture of your setup under your data table.
Repeat steps #2-#4 with your own pulley system.

Analysis: Calculate the Work In (J), Work Out (J), Mechanical Advantage, and Efficiency for each pulley system.

Questions:

1. Do the calculated values of Work Out always equal Work In? Explain.

2. Why do you have to pull the scale at **constant speed**?

3. Were your pulley systems 100% efficient? If not, where does the missing amount of work (energy) go? How might you increase the efficiency?

4. As the number of pulleys increases, what happens to the pulling force required to raise the weight?

5. What happened to the distance that you must pull the string when the number of pulleys is increased?

6. What's the advantage of using a one pulley system? A multiple-pulley system? Is there any disadvantage of using a multiple pulley system?

7. What is the relationship between Mechanical Advantage (MA) and the number of strands of cord supporting the load? Draw a free Body Diagram of the forces acting on the load and use Newton's Laws to justify your conclusions.

8. Do pulleys give you more *energy* out than you put in? If so, explain, if not, explain what they do.

9. If a 500g weight were raised to a height of 15.0 cm and the sting broke, what ***speed*** would it hit the table with?

10. How far would the falling weight in #9 compress a spring with a spring constant of k = 5000 N/m, if the top of the spring was level with the table top?

Error Analysis:

Discuss some possible sources of error in this lab? How could you improve the lab?

Conclusions:

What did you learn? What concepts did you verify? What results did you find? What generalizations can you make about simple machines, pulleys, mechanical advantage, and efficiency?