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M-4 LABORATORY INVESTIGATION

Pulleys as Simple Machines

◆ Pre-Lab Discussion

Pulleys are simple machines that lift objects in a variety of ways. The simplest kind of pulley is a grooved wheel around which a rope is pulled. Pulleys can change the direction of an applied force. For example, a pulley fixed to the top of a flagpole lets you raise a flag *up* by pulling *down*.

A combination of fixed and movable pulleys is a pulley system, or block and tackle. A pulley system multiplies input force to lift heavy objects. Pulley systems are commonly seen on construction sites.

In this investigation, you will use different pulley systems and determine the mechanical advantage of each.

1. Define the mechanical advantage of a machine.

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2. Why is a pulley considered a machine?

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◆ Problem

Advance Preparation: Cut 1 m of fishing line for each group.

How do pulleys help raise objects? How can you find the actual mechanical advantage of a pulley or pulley system?

◆ Materials *(per group)*

2 single pulleys
2 double pulleys
nylon fishing line, 1 m
ring stand
large ring
1,000–g spring scale
500-g mass

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PULLEYS AS SIMPLE MACHINES *(continued)*

◆ Procedure

1. Calibrate the spring scale so that it reads zero when no masses are attached to it.
2. Find the weight of the mass you are using by attaching it directly to the spring scale. Record this weight in the Data Table in Observations as the output force for all the pulley arrangements.
3. Set up a single fixed pulley as shown in Figure 1. Pull down on the spring scale to lift the mass. The reading on the scale shows the amount of input force needed to lift the mass. Record this number in the Data Table.
4. Set up a single movable pulley as shown in Figure 2. Lift the mass by pulling up on the spring scale. The reading on the scale shows the amount of force needed to lift the mass. Record this number in the Data Table.
5. Set up the single fixed and single movable pulley system shown in Figure 3. Measure the amount of force needed to lift the mass and record it in the Data Table.
6. Set up the pulley systems shown in figures 4 and 5. For each pulley system, measure the amount of force needed to lift the mass and record it in the Data Table.
7. Calculate the actual mechanical advantage for each pulley and record it in the Data Table.

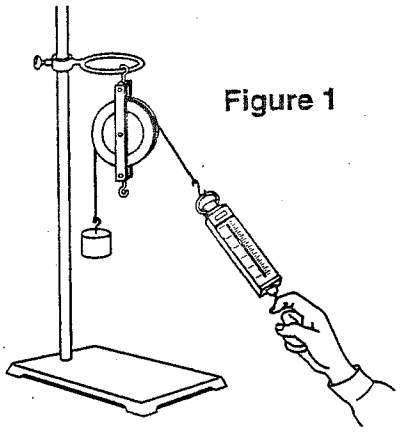

Figure 1

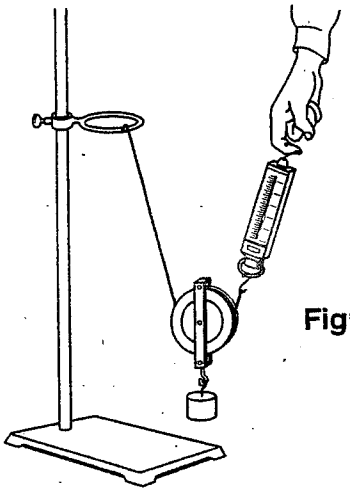

Figure 2

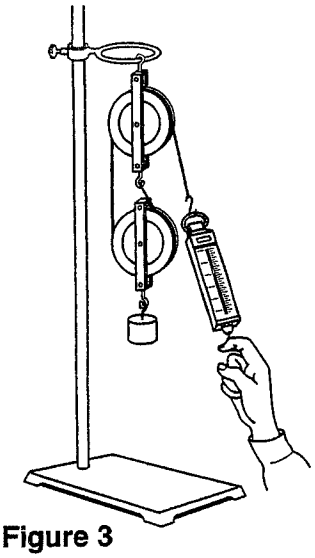

Figure 3

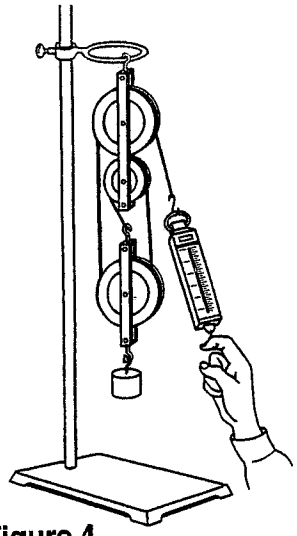

Figure 4

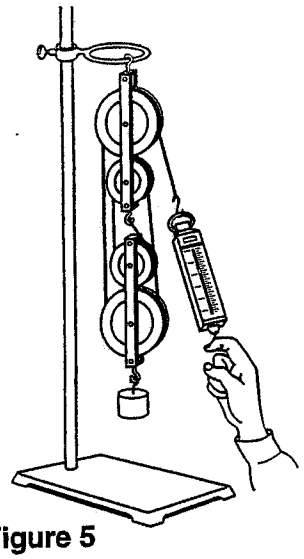

Figure 5

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PULLEYS AS SIMPLE MACHINES *(continued)*

◆ Observations

Data Table

Sample Data

Pulley Arrangements	*Output Force (O)*	*Input Force (I)*	*Actual Mechanical Advantage (O ÷ I)*
Single fixed			
Single movable			
Single fixed and single movable			
Double fixed and single movable			
Double fixed and double movable			

◆ Analyze and Conclude

1. Was there a difference in the mechanical advantages you calculated for the single fixed pulley and the single movable pulley? Give a reason for your answer.

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2. As you added pulleys to the system, what happened to the amount of input force needed to raise the mass?

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3. What factors determine the mechanical advantage of pulley systems?

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◆ Critical Thinking and Applications

1. If a simple machine has a mechanical advantage of 1, input force is not multiplied. Which type of pulley has an ideal mechanical advantage of 1? What is the practical use of this pulley?

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PULLEYS AS SIMPLE MACHINES *(continued)*

2. To determine the ideal mechanical advantage of a pulley or pulley system without calculations, count the number of sections of rope that support the weight. The end section, which is attached to the spring scale, counts as a supporting section *only when pulled upward.* Using figures 1 through 5, determine the number of supporting rope sections for each type of pulley.

a. Figure 1: _____ **c.** Figure 3: _____ **e.** Figure 5: _____

b. Figure 2: _____ **d.** Figure 4: _____

3. Do the values from question 2 agree with the actual mechanical advantage calculated for the Data Table? Why or why not?

_____

_____

_____

4. Draw an arrangement of two double pulleys that would give you a mechanical advantage of 6.

5. When using any simple machine, you never get something for nothing. Although the amount of input force needed to lift a mass is usually less in a pulley system, something else increases. What must increase as the input force decreases?

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6. Explain your answer to question 5 in terms of work input and work output.

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