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Comparing Pulleys

Background Information

One of the most common uses of machines is to increase a force. The force that you exert on a machine is the **input force.** The force that the machine exerts is the **output force.** You can compare the ability of machines to increase input force by determining their actual mechanical advantages. Actual mechanical advantage (AMA) is calculated by dividing the output force by the input force.

$$\text{AMA} = \frac{\text{Output force}}{\text{Input force}}$$

Pulleys are simple machines that are used to lift objects. A pulley consists of a rope wrapped around a wheel. The simplest kind of pulley is a grooved wheel around which a rope is pulled. Pulleys can be used to change the direction of an input force. For example, a pulley attached, or fixed, to the top of a flagpole allows you to raise the flag up by pulling down.

A combination of fixed and movable pulleys is called a pulley system, or block-and-tackle. A pulley system is used to multiply input force so that heavy objects can be lifted. Pulley systems are commonly seen around construction sites.

In this investigation, you will determine the actual mechanical advantage of several different pulleys and pulley systems.

Problem

How do pulleys help to raise objects?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Observing** What is the output force in this investigation?

_____

2. **Inferring** Why will you record the same output force for all the pulleys in this investigation?

_____

_____

_____

3. **Calculating** How will you calculate the actual mechanical advantage of the pulleys in this investigation?

_____

_____

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4. **Predicting** How do you expect the actual mechanical advantage to change as more pulleys are added to the pulley system?

_____

Materials *(per group)*

2 single pulleys
2 double pulleys
1-m nylon fishing line
ring stand
iron ring
10-N spring scale
1-kg mass

Safety

Put on safety goggles. Do not wear open-toed shoes or sandals in the laboratory. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

1 Find the weight of the 1-kg mass by hanging it from the spring scale. Record this weight in the data table as the output force for all of the pulley arrangements.

2. Set up a single fixed pulley, as shown in Figure 1. **CAUTION:** *Make sure that the ring is over the base of the ring stand to reduce the chance that the equipment will tip over.* Pull down on the spring scale to lift the mass. As you do this, observe the reading on the spring scale. Record this value in the data table as the input force.

3. Set up a single movable pulley, as shown in Figure 2. Lift the mass by pulling up on the spring scale. As you do this, observe the reading on the spring scale. Record this value in the data table as the input force.

4. Set up the pulley systems, as shown in Figure 3. For each pulley system, observe the reading on the spring scale as you pull it to lift the mass. Record the value in the data table as the input force for the pulley system.

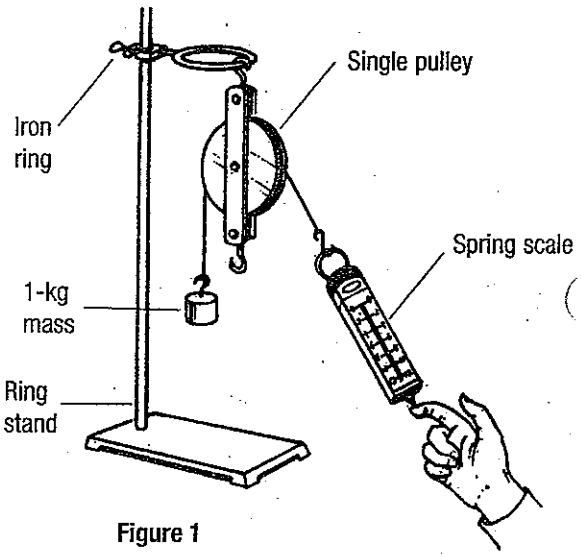

Figure 1

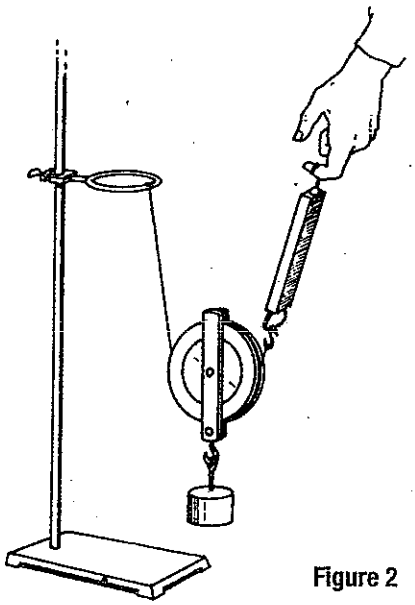
Figure 2

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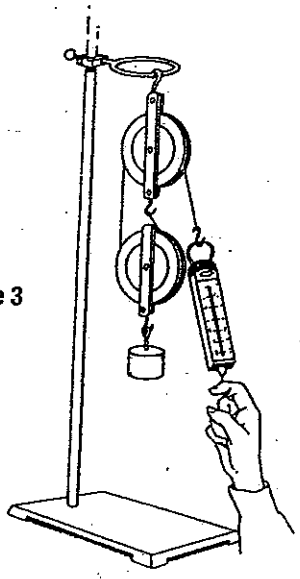
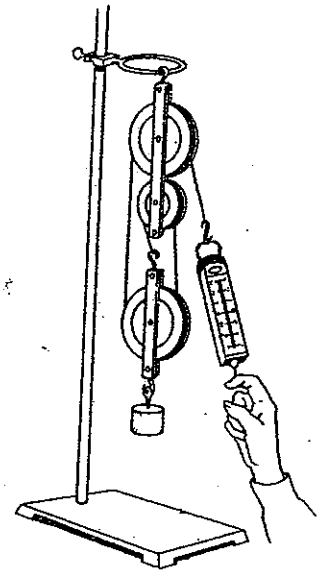
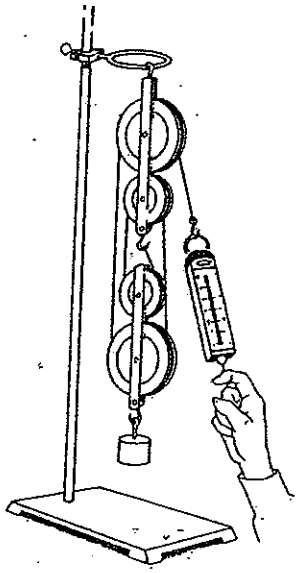
Figure 3



Single Fixed Pulley and Single Movable Pulley



Double Fixed Pulley and Single Movable Pulley



Double Fixed Pulley and Double Movable Pulley

5. Calculate the actual mechanical advantage for each pulley system. To do this, divide the output force by the input force. Record the actual mechanical advantage of each pulley system in the data table.

Observations

DATA TABLE

Pulleys	Output Force (newtons)	Input Force (newtons)	Actual Mechanical Advantage	distance (output) (cm)	distance (input) (cm)
Single fixed					
Single movable					
Single fixed and single movable					
Double fixed and single movable					
Double fixed and double movable					

try to keep constant

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Analysis and Conclusions

1. **Analyzing Data** As you added pulleys to the system, what happened to the amount of effort (input) force needed to raise the mass?

_____

2. **Drawing Conclusions** How did the number of pulleys in the pulley system affect the actual mechanical advantage of the system? Did this result agree with your prediction?

_____

_____

3. **Analyzing Data** What type of pulley produced an output force equal in size to the input force?

_____

4. **Inferring** What is the practical use of a pulley that does not change the size of the input force?

_____

5. **Inferring** When using any simple machine, you never "get something for nothing." Although a pulley system reduces the amount of input force needed to lift a mass, it does so at a cost. What must be increased as the amount of input force is decreased?

_____

6. Calculate the Actual Mechanical Advantage of

Single fixed =

Single fixed single movable =

double fixed double movable =

7. what is the efficiency of the double fixed double movable ? =

8. what is the efficiency of the single fixed? =