Lab 12: Pulleys

Goals

1. Gain a better understanding of simple machines and pulleys

2. Use a pulley and a pulley system

3. Learn more about solving problems using pulleys

Materials and Equipment

Support board
Single and tandem pulley
Cord
Five washers
Spring scale
Tape measure

Materials Not Included

Books to use as weights

Introduction

A **pulley** is a simple machine that can increase a force, increase the distance over which force is applied, or change the direction of the force. If we assume that there is no friction, the effort work (the work going in) equals the resistance work (the work coming out):

(1) $W_e = W_r$

where W_e is the effort work, and W_r is the resistance work. Work (see Lab 10, Work and Power) is defined as force times the distance exerted or:

(2) $W = Fd$

We can combine equations 1 and 2 to form equation 3:

(3) $F_e d_e = F_r d_r$

where F_e is effort force, d_e is effort distance, F_r is resistance force, and d_r is resistance distance.

Any simple machine gives a mechanical advantage, which is the ratio of the resistance force to the effort force:

(4) $MA = \frac{F_r}{F_e}$

where MA is the mechanical advantage, F_r the resistance force, and F_e the effort force. A mechanical advantage of 1.0 yields an effort force equal to the resistance force. Mechanical advantages greater than 1.0 are used to exert a force greater than the effort force. The mechanical advantage of a specific pulley system can be used to predict how much force is needed to lift a certain weight.

Devotional

"God is our refuge and strength, and ever-present help in trouble." Ps. 46:1

Our strength is limited, but God's strength knows no limit. Sometimes I don't feel creative, but one area where you never want to be accused of being creative is the study of theology. If anyone ever tells you that you are doing some creative theology, they are telling you that you are out in left field without a glove.

Somehow bad theology easily slips in. We often say that God is so good or so powerful. While the heart might be right and I'm sure God understands, there is a small but significant error when we add the word "so." The "so" implies that we are closer to accurately describing his goodness or his power than we'd be without using "so." God is good, period, but the "so" adds a measurement of quantity. The implication is that if we take our goodness and keep multiplying it, we can somehow arrive at God's amount of goodness.

In our study of machines, we're learning that we can multiply force or effort to accomplish a greater force than we could without the machine. That does not work in describing God's power, even if we use "so." No matter how large a number you can calculate, it is still nothing compared to infinity or God's power. Subtract the largest number you can imagine from infinity, and you are still left with infinity.

Because God is infinite, his power cannot be used up or depleted. It is no harder for God to move a mountain than it is for him to move a flea. God's strength is infinite and he is omnipresent, so we are always in his presence and he always has more than enough power to take care of the situation.

Paul says in Ephesians 1:18-21 that the same mighty power that raised Jesus from the dead is available to believers. Do you have a problem or situation that seems impossible? God himself said it best when he asked, "Is anything too hard for the LORD?" The obvious answer is no.

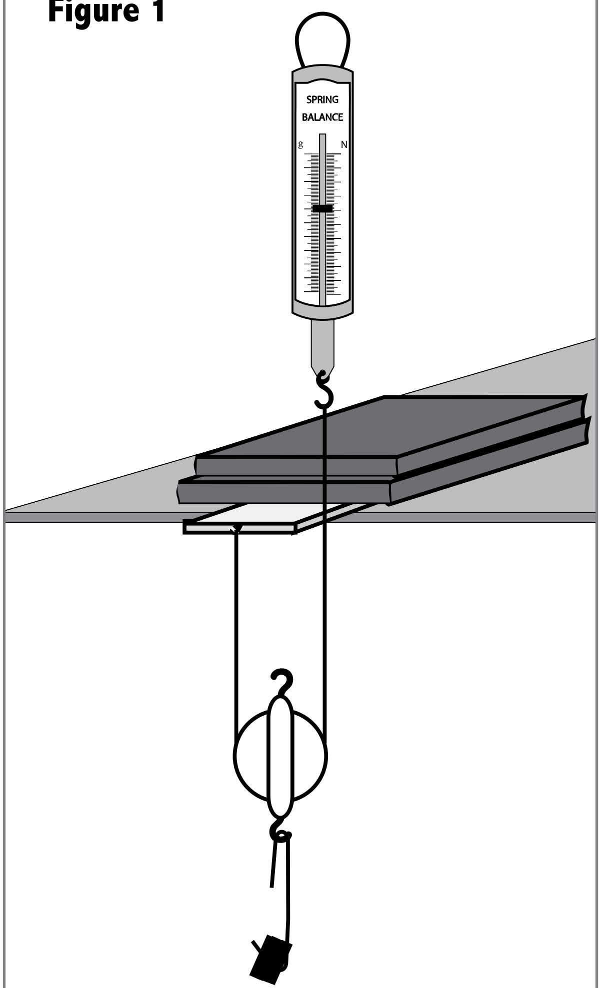
Procedure

You will need to work with a partner because four hands are needed to manipulate the equipment, keep the pulleys in order, and make measurements. During this lab make certain that the cord correctly stays over the pulley(s).

1. Place the support board over the edge of a counter or table and use books as weights to secure it. With the spring scale, weigh the five washers and the single pulley, and record this on the questions page.

2. Attach the cord to the screw of the support board and arrange the pulley and weights as shown in Figure 1. This will be Setup 1 in Table 1. Hang five large washers from the hangers (bent paper clips) used in Lab 11, A Lever. Attach the spring scale at the position of the arrow, and measure

Figure 1



the force needed to hold the washers in position. The resistance force is the total weight of the five washers and the single pulley.

3. Move the spring scale exactly 20 cm and measure the distance the washers moved while the scale moved 20 cm. Record this as d_r in the first column of Table 1.

4. Set up the pulley system as shown in Figure 2. This will be Setup 2. Repeat steps

2 and 3. In this step the resistance force is the total weight of the 5 washers and the tandem pulley.

5. Set up the pulley system as shown in Figure 3. This is Setup 3. Repeat steps 2 and 3. Again, the resistance force is the total weight of the five washers and the tandem pulley

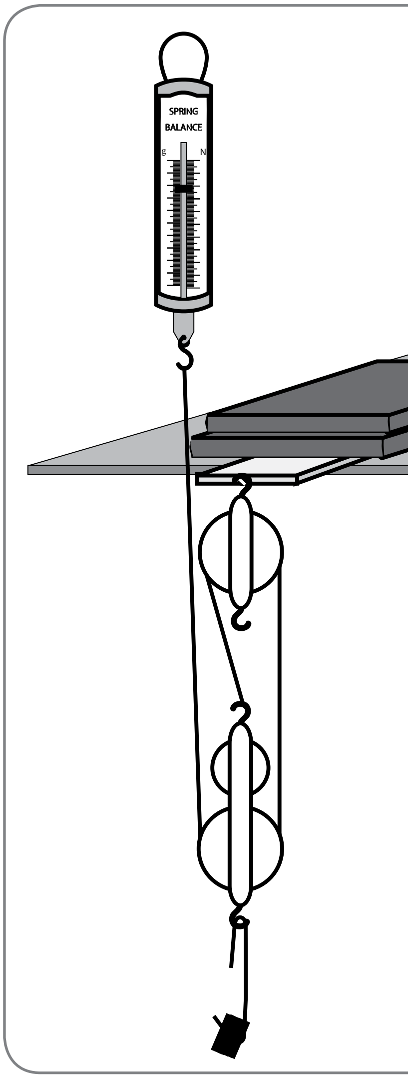


Figure 2

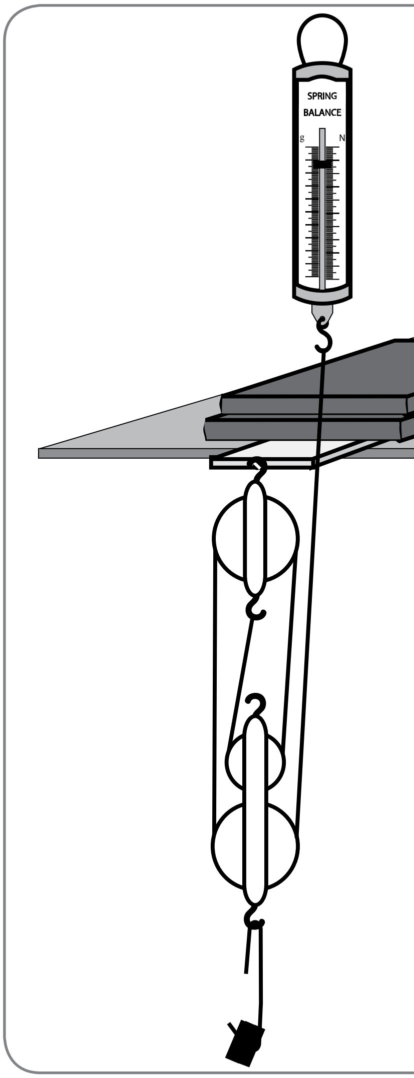


Figure 3

Lab 12

Questions for Pulleys

Table 1, *Force and Distance in Pulleys*

	Setup 1	Setup 2	Setup 3
F_r			
F_e			
d_r			
d_e			
$MA = \frac{F_r}{F_e}$			

Weight of five washers =

Weight of single pulley =

Weight of tandem pulley =

1. Complete Table 1 with your data from the procedures.

2. List the three pulley systems in order of increasing mechanical advantage.

3. Which pulley setup would you prefer to use to help you in lifting a heavy weight? Why?

4. What happens to the distances with that pulley system?

5. A quick way to estimate the ideal mechanical advantage by just looking at a pulley system is to count the number of cords supporting the movable pulley. Try it and record your count.

Pulley system #1 ___________

Pulley system #2 ___________

Pulley system #3 ___________

6. How do the ideal mechanical advantages compare with the actual mechanical advantages that you calculated? What would account for the difference?