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) $MA = \dfrac{F_r}{F_e}$

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.

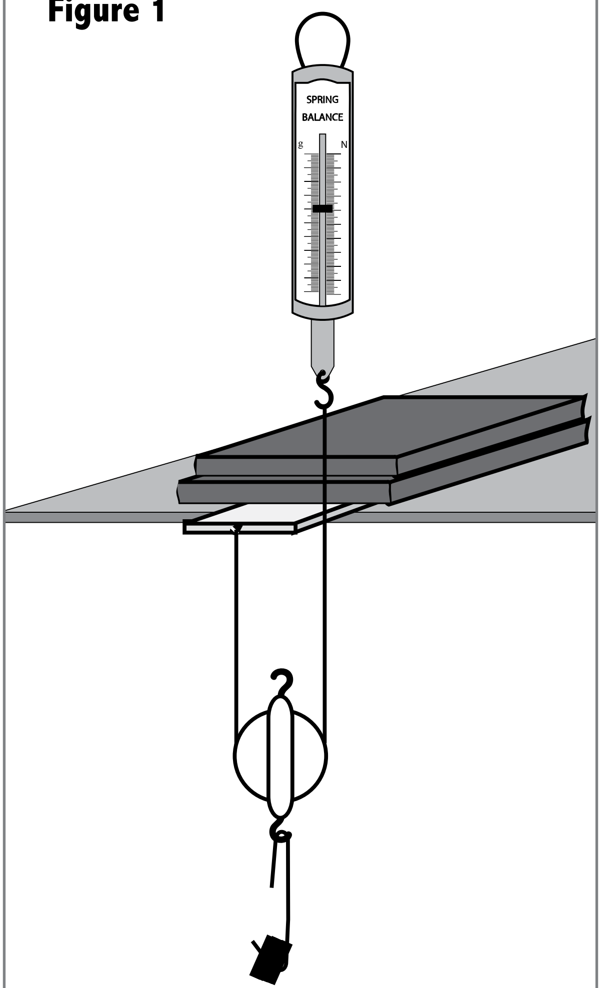
Procedure

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



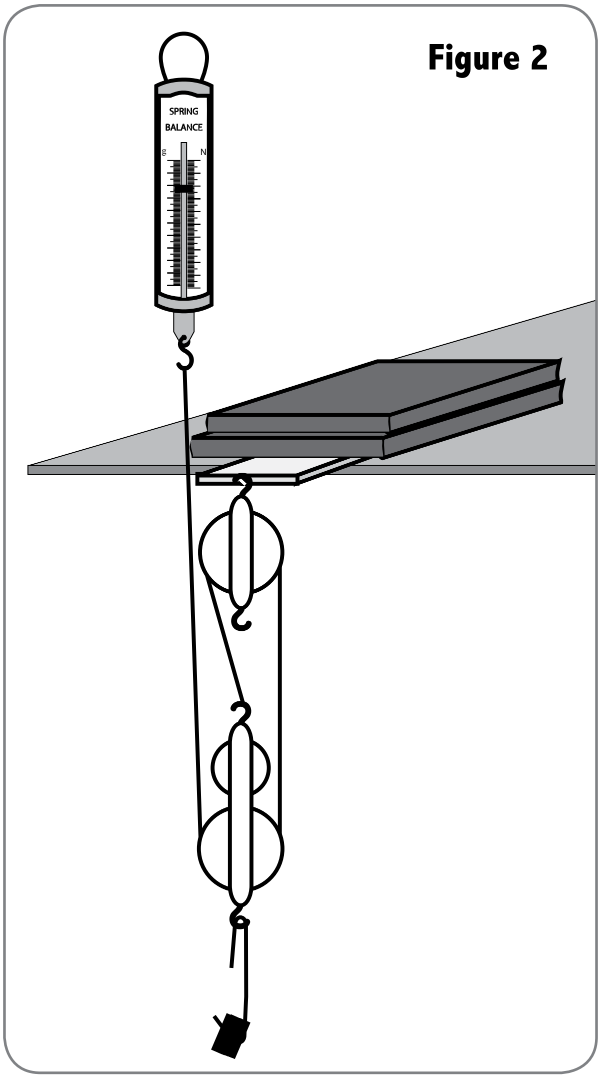
the force needed to hold the washers in position. The resistance force is the total weight of the five washers and the single pulley.

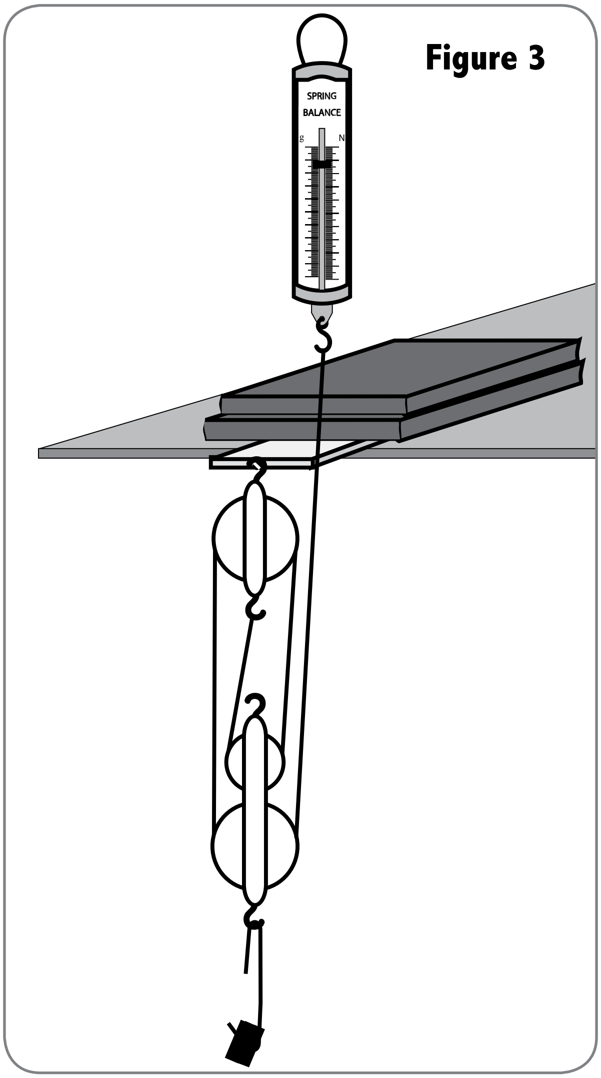
3. Move the spring scale exactly 20 cm and measure the distance the washers moved while the scale moved 20 cm. Record this as d_r in the first column of Table 1.

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





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?

Lab 31: Solution Concentrations

Goals

1. Construct a simple hydrometer

2. Test known sugar solution concentrations

3. Plot a calibration graph

4. Calibrate the hydrometer

5. Use the hydrometer to measure the sugar concentrations of soft drinks

Materials and Equipment

9-inch Plastic pipet
50-mL graduated cylinder
Measuring spoon, 1 cc
Ruler

Materials Not Included

Clear Juices (apple, grape, etc.)
Distilled water
Four small drinking glasses
Graph paper
Sugar
Sugared soda pop

Introduction

When a substance is dissolved in a liquid, the mass of the substance has been added to the liquid, increasing its density. Therefore, measuring the density of a liquid is one way to determine the concentration of the solution if the ingredients are known. A **hydrometer** is a device that can measure the densities of solutions by floating at different levels. The higher the hydrometer floats, the greater is the density of the solution.

Devotional

"As the rain and the snow come down from heaven, and do not return to it without watering the earth and making it bud and flourish, so that it yields seed for the sower and bread for the eater, so is my word that goes out from my mouth: It will not return to me empty, but will accomplish what I desire and achieve the purpose for which I sent it." Isa. 55:10-11

The water cycle is an amazing process that is part of God's creation and plan for life and man's survival on earth. Rain and snow fall to the ground. Snow eventually melts and joins the rain in watering the ground. It also replenishes the groundwater from which we receive our drinking and irrigation water. The excess runs off and joins streams, which merge into rivers and eventually enter the oceans. The heat from the sun evaporates ocean water, which rises to the clouds, which eventually returns to the earth as rain or snow. And that is the water cycle.

Consider some of its features.

1) It needs energy to function, and the sun is its source of energy.

2) It is a worldwide system. No place on earth escapes the blessings of rainfall.

3) The rainfall is almost free of pollutants. The process cleanses itself.

4) Water is conserved, not losing a drop.

5) It is continuous. It doesn't shut down for a rest.

6) It is perpetual. It never needs

restarting, charging, cleaning, feeding, or maintenance.

There are places in the deserts of the world where rain on parched, hard ground can cause a beautiful blanket of flowers to appear seemingly overnight. The wonders of rain are a miracle.

Our Scripture passage likens the effects of rain to the effect of proclaiming God's word. The rain cannot fail but to water the earth and make the plants grow; nor can God's Word fail to accomplish what He intends for it. And that intent is to bring us to the fullness of eternal life. Human intentions fail, but not God's plan.

In history some people have tried to destroy the Bible and all its copies. But human intentions fail. When you see a gentle rain, a thunderstorm, a blizzard, or an ice storm, be reminded that Isaiah used the water cycle to remind us that God's Word never fails.

Procedure

Note for testing sugar concentrations of soda pop: Sodas must be decarbonated before testing because the carbon dioxide bubbles will stick to the hydrometer and affect its buoyancy. Decarbonation takes time, but it can be shortened by the following:
1) pour 50 ml of soda pop into a pan or bowl
2) warm the soda on the stove or in a microwave oven
3) stir the warm the soda
Make certain that you don't overheat the soda so it boils or steams, because that will evaporate the water in the soda and will affect the density. Start the decarbonation at the beginning of the experiment so it has time to sit and cool.

1. Run about one inch of water in a sink. Lay the pipet (hydrometer) in the water and squeeze the bulb to bring in some water. Set it upright and check on the level of water. Adjust the water so that the bulb is full of water and the stem is full of air.

2. Put about 40 mL of water in the 50-mL graduated cylinder. Place the pipet with the bulb down into the cylinder. The pipet should float with the bulb about 2.5 cm below the water line.

3. Tap the side of the cylinder to make certain that the hydrometer is not sticking to the side. Measure the distance (mm) between the water line and the end of the pipet stem, and record in Table 1.

4. Keeping the amount of water in the hydrometer constant, remove the hydrometer, rinse the outside, dry it, and stand it up vertically until it will be used again.

5. Empty the graduated cylinder, rinse it well, and dry it completely.

6. Prepare four sugar solutions and pour each in a drinking glass. Clean the graduated cylinder thoroughly after each preparation. When using the measuring spoon, be careful to level off the top using a knife or ruler.
   4%—Measure out 46 mL of water. Add 2 cc of sugar using the 1-cc plastic measuring spoon and stir thoroughly.
   8%—Measure out 46 mL of water. Add 4 cc of sugar using the 1-cc plastic measuring spoon and stir thoroughly.
   12%—Measure out 46 mL of water. Add 6 cc of sugar using the 1-cc plastic measuring spoon and stir thoroughly.
   16%—Measure out 46 mL of water. Add 8 cc of sugar using the 1-cc plastic measuring spoon and stir thoroughly.

7. Pour about 40 mL of the 4% sugar solution into the graduated cylinder. Place the hydrometer in the cylinder and tap the side of the cylinder to make certain that the hydrometer is not sticking to the side.

8. Measure the distance (mm) between the sugar solution line and the end of the pipet stem, and record in Table 1. See Figure 1.

9. Remove the hydrometer, rinse the outside, dry it, and stand it up vertically so it can be used again. Empty the graduated

cylinder, rinse it well, and dry it completely.

10. Repeat procedures 7, 8, and 9 with the 8%, 12%, and 16% sugar solutions.

11. Prepare a graph of pipet stem height (vertical axis) versus sugar concentration (%).

12. Plot the data from Table 1 on the your graph. Note that the points are almost in a straight diagonal line. Draw a straight line through the midst of the points. This graph is the calibration device for the remainder of the experiment.

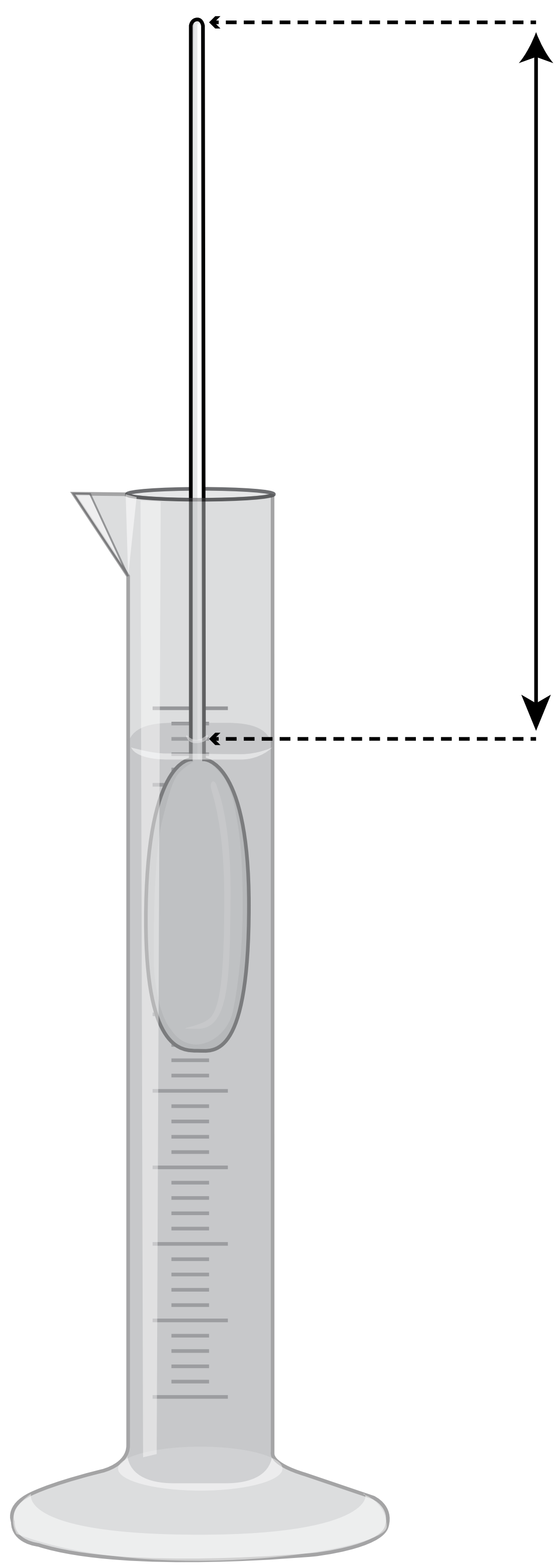
13. Prepare the beverages for testing. You will probably need less than 50 mL of each sample, as long as the pipet floats freely. Write the name of each beverage in Table 2.

14. For each sample tested you will follow the same procedure as used previously. Measure the pipet stem height above the water, and record this distance in Table 2.

15. Now you will use the calibration graph to determine the percentage of sugar in each sample. For each sample: (1) Find the stem height on the graph; (2) draw a horizontal line from the vertical axis to the calibration (diagonal) line; and (3) at that intersection draw a vertical line down to the horizontal axis. The percentage that it crosses is the percentage of this tested drink.

16. Write the concentration percentage of each drink on Table 2.

Figure 1



Lab 31

Questions for Solution Concentrations

Table 1

Concentration of Sugar Solutions (%)	Stem Height above solution (mm)
0 (water)	
4	
8	
12	
16	

Table 2

Name of Drink	Stem Height (mm)	Sugar Percentage (%)

1. Did you expect as much sugar in the beverages tested? Which was the most surprising?

2. While this experiment tested for the sugar percentage, what factors could cause the results to be somewhat off?