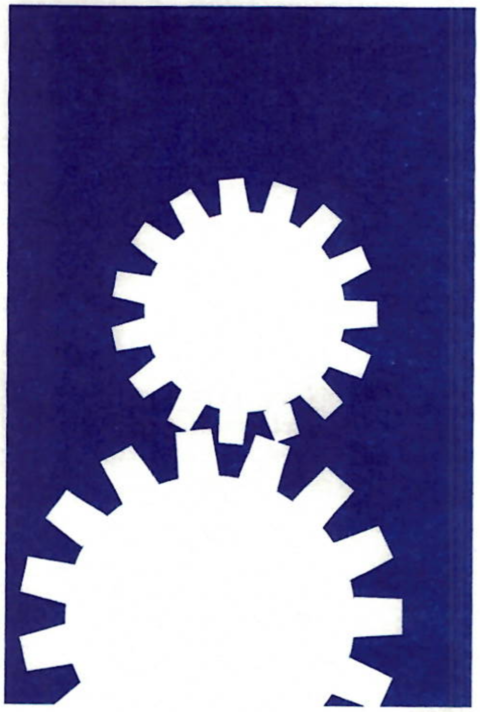
discovery kits



SIMPLE MACHINES
65559-05

STUDENT'S WORKBOOK

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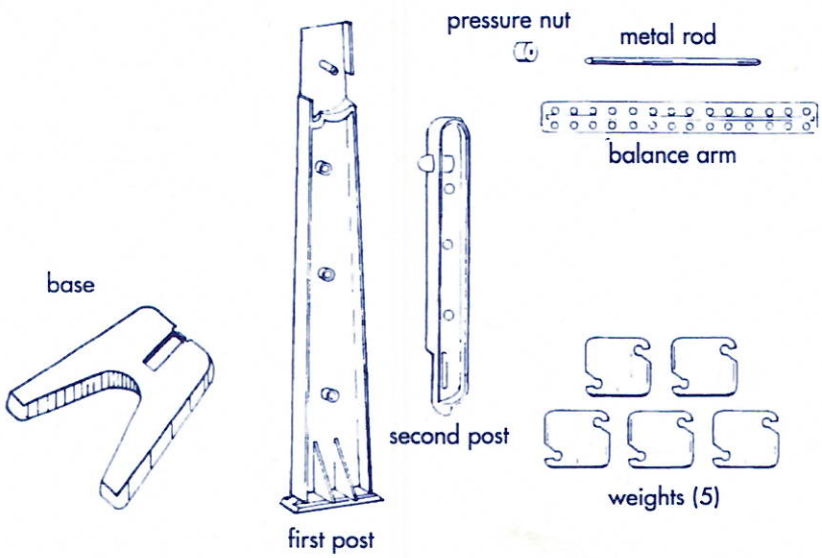
INTRODUCTION

Levers, wheels and axles, pulleys and gears can help you do more things than you could without them. They are used in things like cars, clocks, bicycles, eggbeaters, baseball bats and fishing rods.

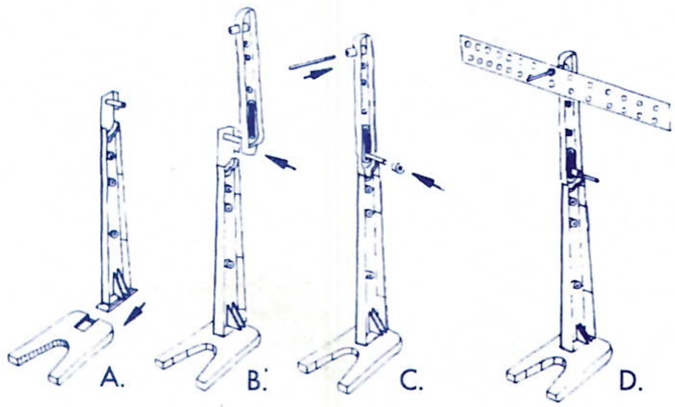
This workbook is divided into four parts: Levers, Wheels and Axles, Pulleys and Gears. At the beginning of each part are pictures of the pieces you will need from your Discovery Kit and how to assemble them. Look at the assembly picture carefully to be sure you understand it before you put the pieces together.

Part 1: Levers

A balance arm is one kind of lever. If a weight is placed on one end, the arm becomes unbalanced. Putting another weight on the other end, or pushing down on it lightly, will balance the arm again. To build a balance arm, you need the following pieces from your Discovery Kit:

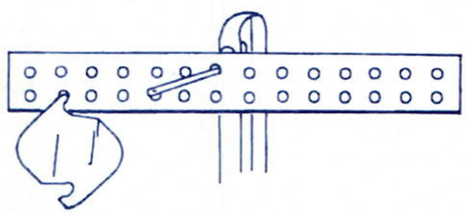


To assemble, slide the first post into the base. Attach the second post to the first post and fasten with the pressure nut. Push the metal rod into the hole at the top of the second post. Turn the balance arm so that the side with the holes numbered from the center in both directions faces you. Slide the top unnumbered center hole onto the metal rod. If the arm doesn't balance, put small bits of clay on the lighter side until it does balance.

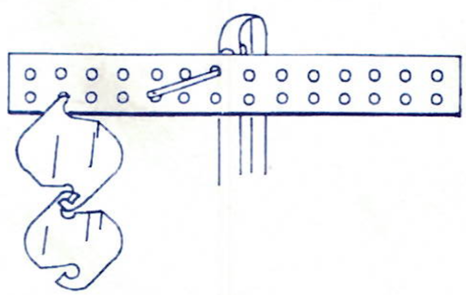


Exploration 1: Simple Balance

Hang one weight on the left side of the balance arm. Where must you hang a second weight to balance it?



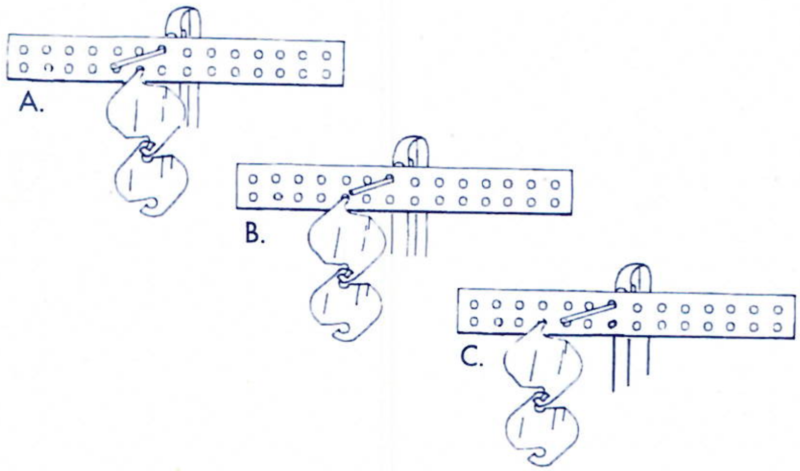
Hang two weights on the left side of the balance arm. Where should you hang two other weights to balance the arm?



What rule can you make up to explain to someone else how to balance weights on a balance arm?

Exploration 2: Taking Data

Hang two weights one hole from the center on the left side of the arm and balance them with weights on the right side. Move the weights on the left side over one space to the left and balance the arm again. Prepare a table like the one below, and record what you must do to the right side to balance the arm each time you move the weights on the left side.



TABLE

LEFT SIDE		RIGHT SIDE	
Number of Weights	Number of Holes from Center	Number of Holes from Center	Number of Weights
2	1	–	–
2	2	–	–
2	3	–	–
2	4	–	–

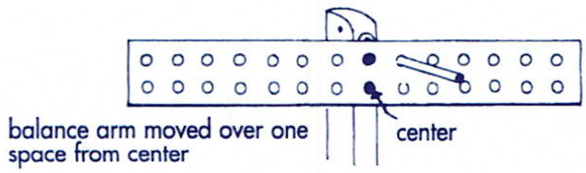
Now hang two weights on the left side and balance them with only one weight on the right side. Make a new table and repeat the above experience, moving the left hand weights one hole each time, and balancing them with a single weight on the right. When you are through, look carefully at the table. What patterns do you see?

Try this with three weights on the left, and one or two on the right. Keep a table of a data. What pattern do you see now?

What rule would you make up to explain how you can use fewer weights to balance the arm?

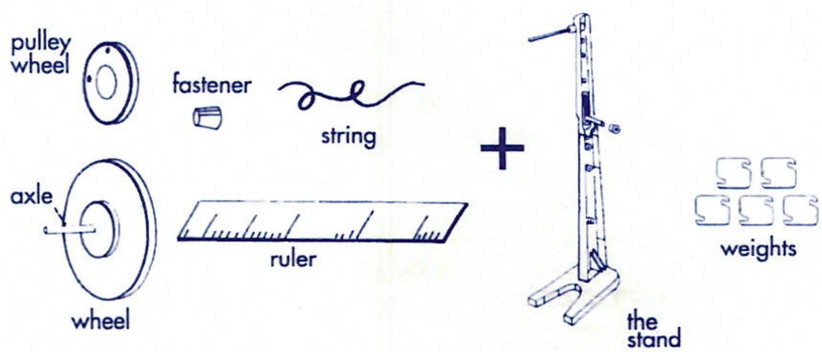
Additional Explorations

1) How would you balance three weights in the second hole on the left side with only two weights on the right side? Can you do it three different ways? (Hint: The two weights don't have to hang from the same hole.)
2) Hang the balance arm one hole from the center. Repeat Explorations 1 and 2. What new facts and patterns do you discover?

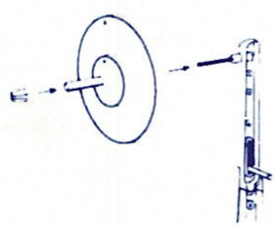


Part II: Wheels and Axles

The wheel and the axle form a turning lever; when you turn the wheel the axle also turns. For this experience, you will need the following materials:



Remove the balance arm and weights from the stand you assembled before. Attach the wheel and axle assembly to the stand using the fastener as shown.



Exploration 1: Leverage of Wheels/Axles

Turn the wheel. Now turn the axle. Which is easier to turn? Look at a doorknob: Which part is the wheel and which is the axle? Would a door be easier to open if the wheel were larger?

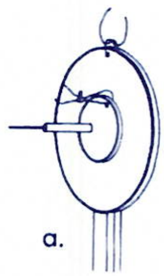
Exploration 2: Leverage of Two Wheels

Notice that the wheel has a smaller wheel attached to it. Use your ruler to measure the diameters of both the outer wheel and the inner wheel. Record the sizes on a table like the one below.

TABLE

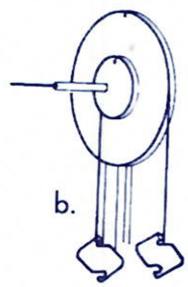
Diameter of outer wheel ________ Diameter of inner wheel ________	
Outer Wheel (Number of weights)	Inner Wheel (Axle) (Number of weights)
1 2	_ _

Cut the string in half. Thread one piece through the hole near the edge of the outer wheel and tie it. You will need the string again so be sure to tie all knots so that they are easy to untie. Run the string clockwise along the outer groove, and tie a weight to the end.



a.

Thread the other piece of string through the two holes on the inner wheel and tie it. Run the string counter-clockwise along the inner groove. Tie a weight to the end of the string. Does it balance? Do you need to add another weight to the inner wheel?



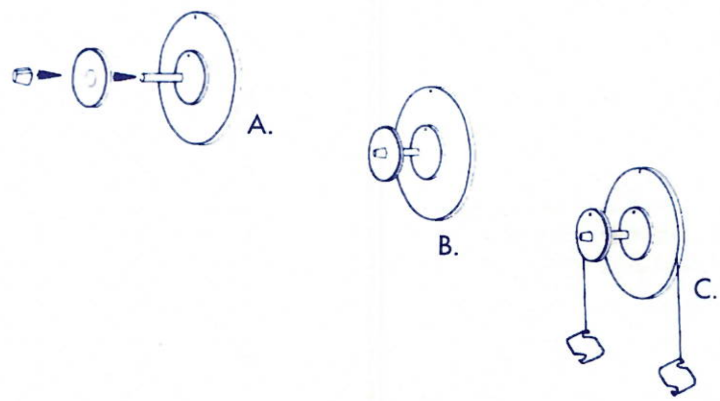
b.

Using your table above, record how many weights it takes to make the wheels balance.

What pattern do you see between the number of weights and the diameter of the wheels? Is this anything like you observed in working with the balance arm and weights?

Exploration 3: Large Wheel vs. Small Wheel

Measure the diameter of one of the small pulley wheels and place it on the axle. Remove the string from the inner wheel. Tie it to the hole in the small pulley the same way you did with wheels. Repeat Exploration 2, substituting the pulley for the inner wheel. Keep a record of the data.

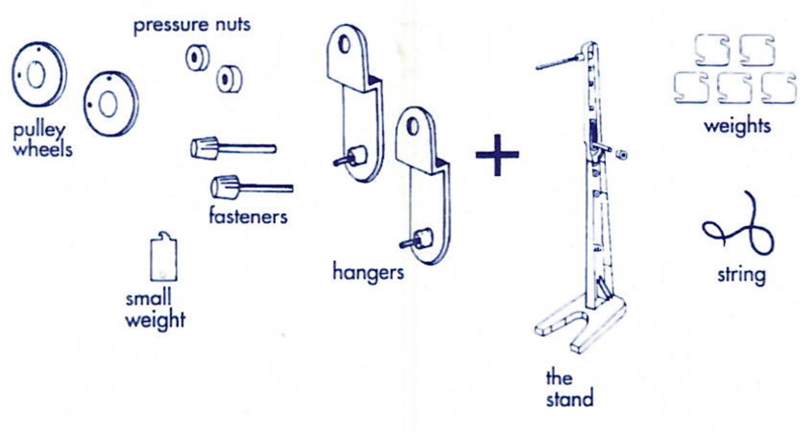


What patterns are shown by the new table? How are these patterns like those in your first table?

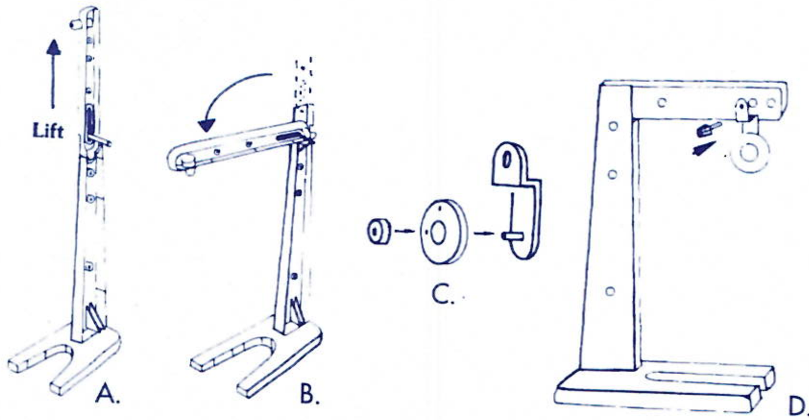
How do your tables explain why it is hard to open a door by turning only the axle?

Part III: Pulleys

Pulleys can help make work easier in many ways. You need the following materials for this experience.

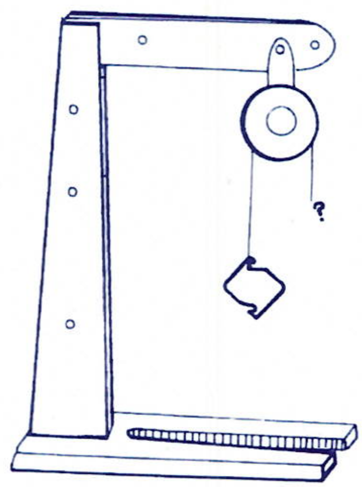


Move the second post of the stand so that is is horizontal. Attach one pulley to a hanger with a pressure nut. Push the hanger into the middle hole of the stand as shown.



Exploration 1: The Fixed Pulley

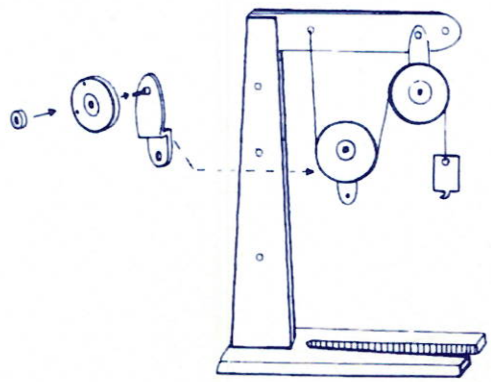
Remove the strings from the wheel and axle. Hang one piece over the pulley and attach a weight to one end. How many weights must you hang on the other end of the string to balance the pulley system? How many weights would you need if 2 or 3 weights were hung from one end?



Is this pulley like a wheel and axle? Is it like a lever? Why do you think it is called a "fixed pulley"?

Exploration 2: Two Pulleys

Take the weights off the string. Move the pulley and hanger over to the last hole on the stand. Tie one end of the string to the first hole on the stand. Assemble the second pulley and hang it on the string as shown below. (You can balance the system by hanging the small square weight on the end of the string.)



Why do you think this second pulley is called a "moveable pulley"? If you hang one weight from the moveable pulley, how many weights must you hang on the end of the string to balance it? Hang two weights on the moveable pulley. How many weights must you hang on the end of the string to balance these? Hang four weights on the moveable pulley and determine the number to be hung on the string.

How do pulleys make work easier? In what ways are pulleys like levers?

Additional Explorations

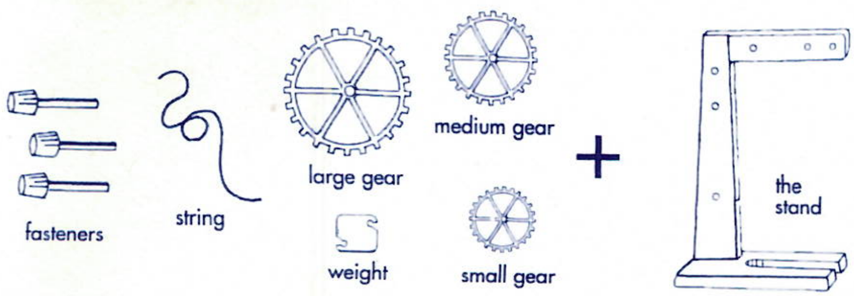
Using the pulley system from Exploration 2, measure the distance moved by the moveable pulley and the length of the string (from the fixed pulley) when the pulleys are balanced with weights. Record your results in the table below. What patterns can you find in the table? Are these like the patterns you found when you investigated levers?

TABLE

Number of weights on moveable pulley: ______ Number of weights on fixed pulley: ______	Distance moveable pulley moves: 1 inches Distance string moves from fixed pulley: ______
Number of weights on moveable pulley: ______ Number of weights on fixed pulley: ______	Distance moveable pulley moves:__ inches Distance string moves from fixed pulley: ______
Number of weights on moveable pulley: ______ Number of weights on fixed pulley: ______	Distance moveable pulley moves: 3 inches Distance string moves from fixed pulley: ______

Part IV: Gears

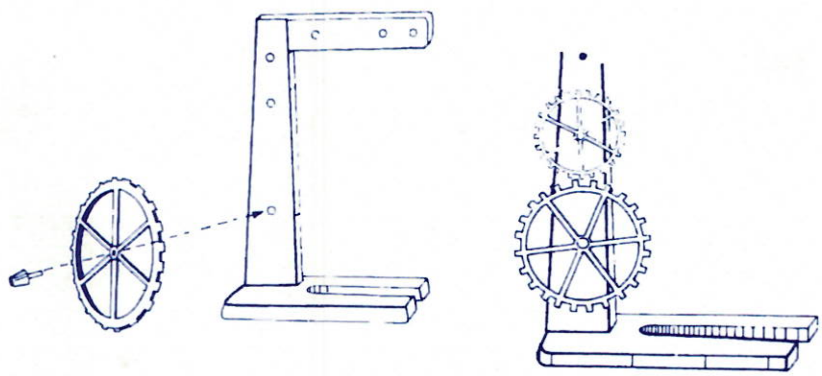
A gear is like a wheel with teeth around the edge. When the teeth on two gears are meshed, one will turn the other without slipping. You will need the following parts in studying gears.



Before you assemble the parts, use a magic marker or a tiny piece of colored tape to make a dot on one tooth of each of the three gears. This will make it easier for you to count the number of times each gear turns during the explorations.

Exploration 1: Two Gears

Attach the two largest gears to the stand as shown. Make sure that the sides with the dots are facing out. Turn the large gear to the right, then to the left. What does the medium gear do? Now arrange the gears so the dots are at the top. Turn the large gear around once. How many times did the medium gear turn? Did it turn faster or slower than the large gear?

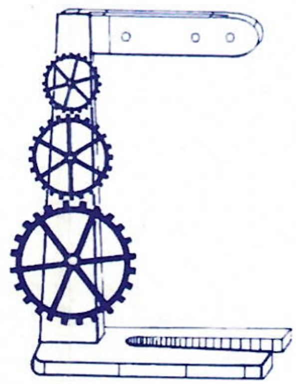


Turn the medium gear around once. How many times did the large gear turn? Did it turn faster or slower than the medium gear?

If you want something to turn faster, to which gear would you apply your effort?

Exploration 2: Three Gears

Add the small gear to the top of the stand. Arrange the gears so that all the dots are at the top. Turn the large gear to the right, then to the left. Which way did the small gear turn? Which way would a fourth gear turn if it were in the gear train? The fifth gear? Can you predict the direction for eight gears? For eleven gears?



Turn the gears so all the dots are at the top. Turn the large gear around once. How many times did the small gear turn? Did it turn faster or slower than the large gear?

Turn the small gear around once. How many times did the large gear turn? Did it turn faster or slower than the small gear? How many times must you turn the small gear around before the large gear turns around once?

Exploration 3: Gear Teeth and Rotation

Count the number of teeth on each gear. What pattern do you see between the number of teeth and the number of times a gear turns? Make a table showing your results.

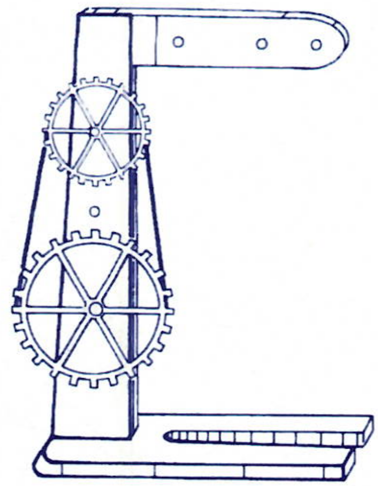
TABLE

NUMBER OF TEETH ON LARGE GEAR: 30	NUMBER OF TEETH ON MEDIUM GEAR: ___	NUMBER OF TEETH ON SMALL GEAR: ___
Number of Turns	Number of Turns	Number of Turns
1	—	—
2	—	—
3	—	—
4	—	—

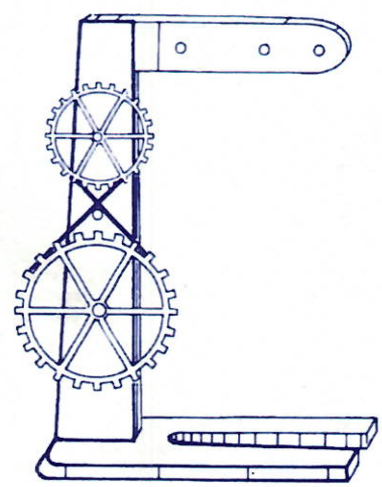
If you wanted to make something turn more slowly, which gear would you turn? What is the advantage of using three gears instead of two? How could you put these gears to work?

Exploration 4: Gears and Belt Drive

You will need two rubber bands for this exploration. Assemble the two largest gears as shown and fasten one of the rubber bands around them. Turn the large gear to the right, then to the left. What did you notice about the upper gear? Did it turn faster or slower than the large gear?

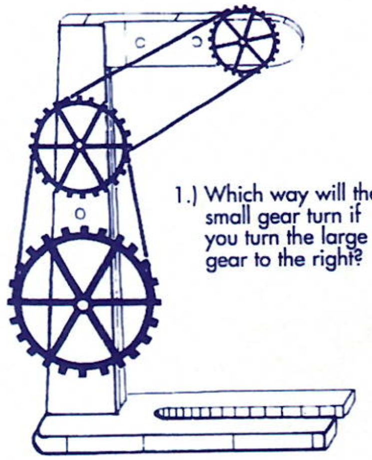


Fasten the rubber band so it crosses itself between the gears as shown in the sketch.

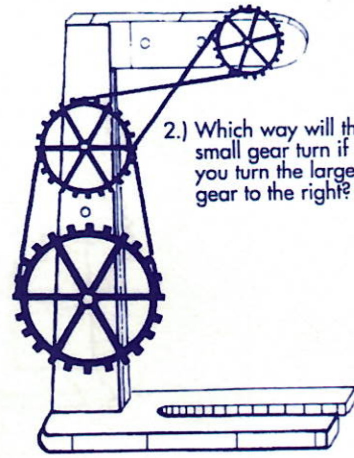


Turn the largest gear. What happens to the upper gear? Did you expect that to happen?

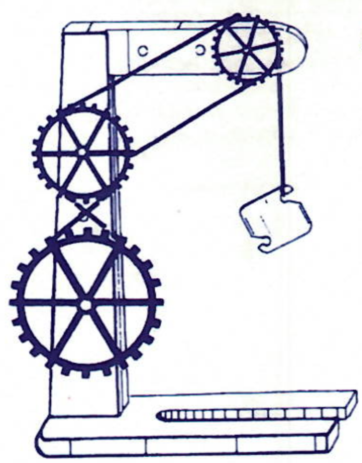
The sketches below show three arrangements of the gears, rubber bands, and strings. Look at the pictures and then answer the questions. (Hint: In the third picture, the string holding the weight is tied to the pulley on the gear so it does not slip.)



1.) Which way will the small gear turn if you turn the large gear to the right?



2.) Which way will the small gear turn if you turn the large gear to the right?



3.) Will the weight go up or down when you turn the large gear to the right?

Additional Explorations

1) Using three gears and string, how would you arrange them so you could slowly lift an object?
2) See how many pieces of this kit you can use in building a complex machine. Try to use all of them.

Dr. Lawrence F. Lowery is a professor of science education at the University of California, Berkeley. He has had extensive elementary and junior high school teaching experience, has written numerous films and books on science and has written many articles for teachers on science instruction.

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