Simple Machines -- Inclined Planes

Any slope along which an object (a resistance force) is moved from one level to another level is considered an inclined plane. Stairs, ramps, and roadways that go uphill are examples of inclined planes. In this investigation you will see how an inclined plane makes work easier.

QUESTION: How does an inclined plane make it easier to move a book from the table to the top of a stack of books? (and since we know we cannot get something for nothing, what is the tradeoff?)

MATERIALS: string (60 cm), 5 text books, small book, spring scale, board, meterstick

1. Stack five books and rest one end of the board on the top of them. Measure the height of the stack and the length of the board.

   Height of stack ______ **Length of Board** _____

2. Tie the string into a loop. Place around the binding of the small book. Hook the string onto the spring scale.

3. Suspend the book just above the table. Record the force needed to do this. This is the **resistance or load force** = _________.

4. Next, raise the book straight up the height of the stack and measure the force needed to do this.

   Straight Up (Load) Force _____ **Straight Up Distance** ______

5. Place the book on its side at the bottom of the inclined plane. While pulling the book up the ramp with the spring scale, measure the force needed to do this.

   Inclined Plane (Effort) Force _____ **Inclined Plane Distance** ______

6. Return all the materials. Answer questions on the back of this sheet.

QUESTIONS

1. Describe the two methods used to raise the book to the top of the stack.

   Step 4 ____

   Step 5 ____

2. Was the book raised the same height in the two methods? __________

3. Was there a difference in the two methods in the amount of force needed to raise the book? Explain.

4. Was there a difference in the two methods in the distance the book was moved? Explain.

5. Was the method that required you to move the book a greater distance the same method that saved you some effort force? ______

6. Calculate the mechanical advantage of the inclined plane MA=RF/EF

7. Did the inclined plane make work easier?

8. Did the inclined plane reduce the amount of work required to move the book? Explain.

9. What is the tradeoff when using an inclined plane? In other words, how does an inclined plane make our work easier? (HINT: use force and distance in your answer)

Name ______________________ Class ____________ Date ________

Laboratory Investigation

Simple Machines—Levers

Background Information

Simple machines make work easier to do. One way to express the benefit ot using machines is called mechanical advantage (MA). The mechanical advantage of a machine is a number without units. If the mechanical advantage is more than 1, the machine makes work easier by multiplying the effort force. In other words, it causes an effort to seem larger than it actually is when acting against a resistance. If the mechanical advantage is less than 1, the machine makes work easier by allowing the resistance to move farther and faster than the effort. If the mechanical advantage is exactly 1, the machine makes work easier by changing the direction in which the effort must be applied.

A lever is a simple machine that involves two forces and a pivot point called a fulcrum. The force the user applies to the lever is called the effort or the effort force. The force against which the effort acts is called the resistance or the resistance force.

There are three classes of levers. The position of the two forces with respect to the fulcrum determines the class of the lever. In this investigation you will see how different positions of the effort, resistance, and fulcrum affect the mechanical advantage of the lever.

Problem

How does changing the positions of the effort, resistance, and fulcrum affect the mechanical advantage of a lever?

Materials *(per group)*

meterstick
spring balance
weights (.5N, 2N, 5N)
meterstick clamp or holder to serve as fulcrum

Procedure

1. Hang the mass from the spring balance to determine its force (weight) in newtons. Record this number in Observations as R.
2. Set up a first-class lever with the fulcrum at the 50-cm mark on the meterstick. Place the resistance (mass) and the effort (spring balance) at the distances indicated as resistance distance and effort distance, respectively, in A of Data Table 1. The effort force is the reading on the spring balance when the balance just balances the resistance. Calculate the mechanical advantage for this first-class lever. Record in Data Table 1.
3. Repeat step 2 three more times using the effort distances and resistance distances given for positions B, C, and D in Data Table 1.

4. Set up a second-class lever with the fulcrum 10 cm from the end of the meterstick. Place the resistance (mass) and the effort (spring scale) at the distances indicated in A of Data Table 2. Apply the effort and record the effort force reading on the spring scale. Calculate the mechanical advantage for this second-class lever. Record in Data Table 2.

5. Repeat step 4 two more times using the distances given for positions B and C in Data Table 2.

6. For the third-class lever, do not use the meterstick clamp as the fulcrum. Place the end of the meterstick on the tabletop. This will be your fulcrum. Place the resistance (mass) and the effort (spring scale) at the distances indicated in A of Data Table 3. Apply the effort and record the effort force reading on the spring scale. Calculate the mechanical advantage for this third-class lever. Record in Data Table 3.

7. Repeat step 6 two more times using the distances given for positions B and C in Data Table 3.

Observations

R = 5 N.

DATA TABLE 1 First-Class Lever: Fulcrum at 50 cm

Position	Effort Distance	Resistance Distance	Effort Force	Mechanical Advantage $\left(\frac{R}{E}\right)$
A	40 cm	40 cm		
B	40 cm	20 cm		
C	40 cm	10 cm		
D	20 cm	40 cm		

R= 2 N

DATA TABLE 2 Second-Class Lever: Fulcrum at 10 cm from end of meterstick

Position	Effort Distance	Resistance Distance	Effort Force	Mechanical Advantage $\left(\frac{R}{E}\right)$
A	50 cm	40 cm		
B	50 cm	25 cm		
C	50 cm	10 cm		

R= .5 N

DATA TABLE 3 Third-Class Lever

Position	Effort Distance	Resistance Distance	Effort Force	Mechanical Advantage $\left(\frac{R}{E}\right)$
A	20 cm	80 cm		
B	40 cm	80 cm		
C	60 cm	80 cm		

Name ________________________________ Class ______________ Date __________

Analysis and Conclusions

1. In the first-class lever, how did the effort force compare with the resistance force when the effort distance was equal to the resistance distance?

____

2. What was the mechanical advantage of the first-class lever in which the effort distance was equal to the resistance distance? ______________________

____

3. In the second-class lever, how does the effort force compare with the resistance force?

____

4. In the second-class lever, was the mechanical advantage the lowest when the resistance was close to the fulcrum or close to the effort? ______________________

____

5. In the second-class lever, was the mechanical advantage the greatest when the resistance was close to the fulcrum or close to the effort?

____

____

6. Which third-class lever had the greatest mechanical advantage?

____

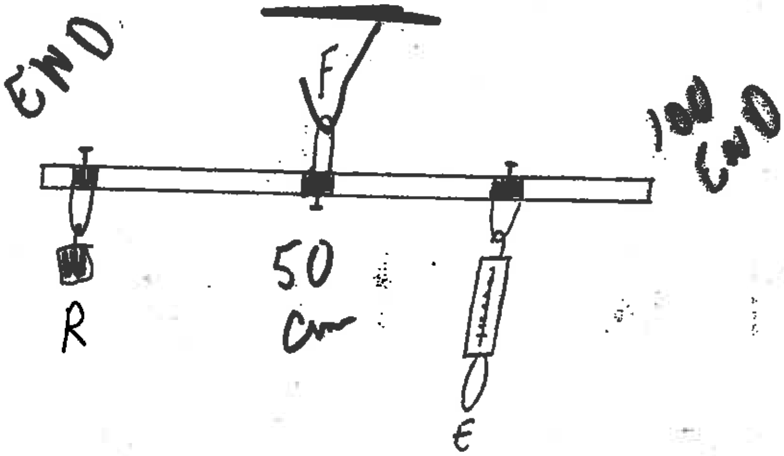
____

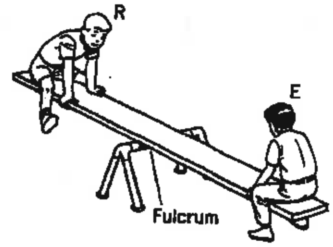
7. Which third-class lever had the least mechanical advantage?

____

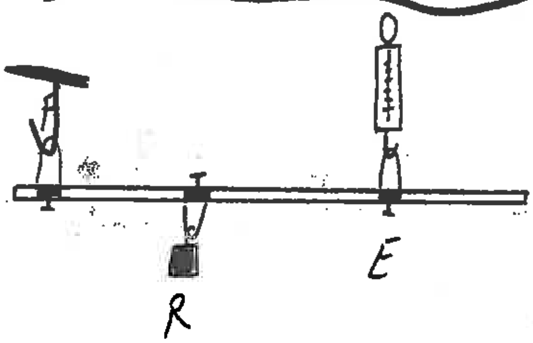
____

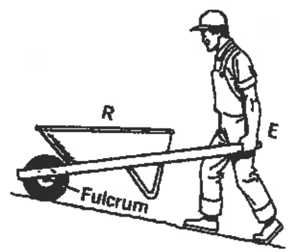
FIRST CLASS LEVER



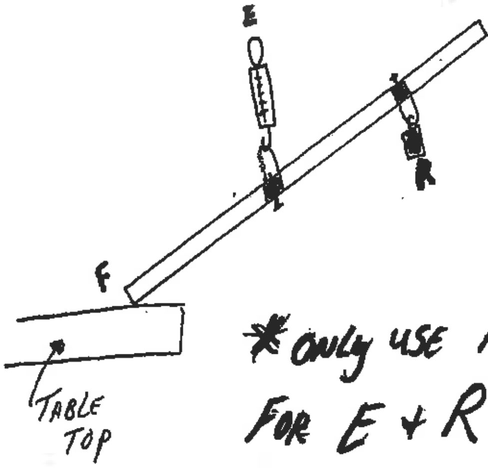


SECOND CLASS LEVER



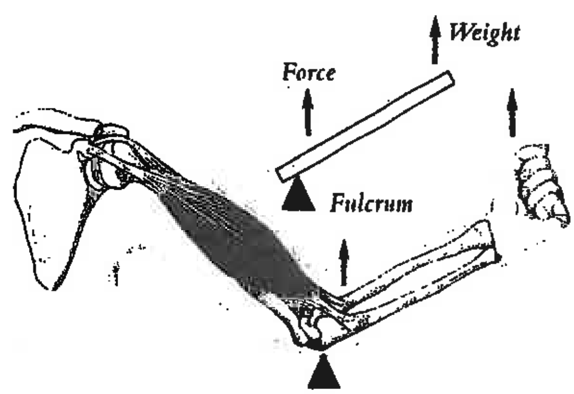


3RD CLASS LEVER



*ONLY USE A CLAMP FOR E + R

*NO CLAMP FOR F



Science 9
Gear Lab

INTRODUCTION: 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. Before you do the lab, **check to see that one tooth of the four gears has a red dot on it.** This will make it easier for you to count the number of times each gear turns during the lab.

MATERIALS: fasteners, gear wheels, gear holder

PROCEDURE:

PART 1: TWO GEARS

1. Attach two gears to the holder so their teeth mesh. Make sure you can see the red dot on each gear you use.

2. Turn one of the gears to the right, and then to the left.

   What happens to the other gear?..

3. Now arrange the two gears so the dots are at the top. Turn the larger of the two gears **once**.

   How many times did the smaller gear turn?.............................

   Did it turn faster or slower than the larger gear?.......................

4. Arrange the gears so the red dots are at the top, and turn the smaller gear around **once**.

   How many times did the larger gear turn?..................................

   Did it turn faster or slower than the smaller one?.......................

PART 2: THREE GEARS

1. Place three gears on the holder so each gears meshes with the one next to it. Arrange the gears so all of the red dots are on the top. Turns the largest of the three gears to the right and then to the left.

   Which way did the smallest gear turn?..

2. Arrange the gears so all of the red dots are on the top again. Turn the largest gear around **once**.

How many times did the smallest gear turn?..................................
Did the smallest gear turn faster or slower than the largest gear?....................................

3. Rearrange the gears so all of the red dots are on the top again. Turn the smallest gear around **once.**

How many times did the largest gear turn?...................................

Did it turn faster or slower than the smallest gear?.....................
How many times must you turn the smallest gear around before the largest gear turns around once?..................................

PART 3: GEAR TEETH AND ROTATION:

1. Count the number of teeth on each gear and record it on the Data Table.

Data Table

Number of teeth			
largest gear......	next largest.....	next largest.....	smallest.....
No. of turns	No. of turns	No. of turns	No. of turns
1			
2			
3			
4			

What pattern do you see between the number of teeth and the number of times a gear turns?

ANALYSIS AND CONCLUSION QUESTIONS:

1. If you have two different sized gears working together, to which gear would you apply your effort force to increase the speed?

2. What would be the advantage of using three gears meshed together?

3. To find the mechanical advantage of a set of gears, use the following equation:

$$MA = \frac{\text{number of \textbf{driven} teeth}}{\text{number of \textbf{driving} teeth}}$$

Calculate the MA of the gears when the largest gear is **driving** the smallest gear.

Calculate the MA of the gears when the smallest gear is **driving** the largest gear.

4. When would you want the smallest gear driving the largest gear?

5. When would you want the largest gear driving the smallest gear?

Name ______________________ Class ______________ Date ____________

Laboratory Investigation

Simple Machines

Pulleys As Simple Machines

Background Information

Pulleys are simple machines that are used in different ways to lift objects. 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 applied 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 effort force in lifting heavy objects. Pulley systems are commonly seen around construction sites.

In this investigation you will see how different pulleys are used and determine the mechanical advantage of each.

Problem

How are pulleys used to raise objects? How is the mechanical advantage of a pulley or pulley system determined?

Materials *(per group)*

2 single pulleys
2 double tandem pulleys
1 500g WEIGHT
SHORT STRING
ring stand and large ring
spring balance
LONG STRING

Procedure

1. Find the resistance force of the mass you are using by attaching it directly to the spring balance. Record this resistance in the Data Table as the resistance for all of the pulley arrangements.

2. Set up a single fixed pulley as shown in Figure 1. Pull down on the spring balance to lift the mass. The reading on the balance shows the amount of effort needed to lift the resistance. Record this number in the Data Table.

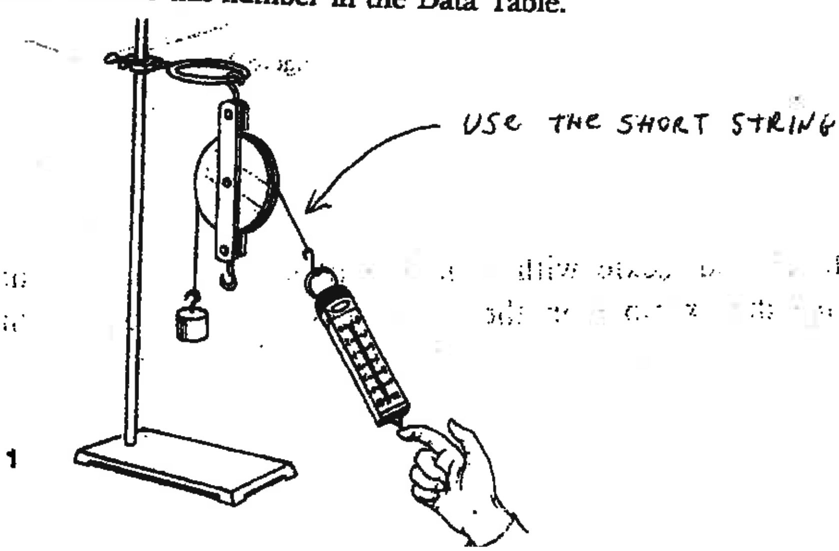


Figure 1

3. 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 balance shows the amount of effort needed to lift the resistance. Record this number in the Data Table.

USE THE SHORT STRING

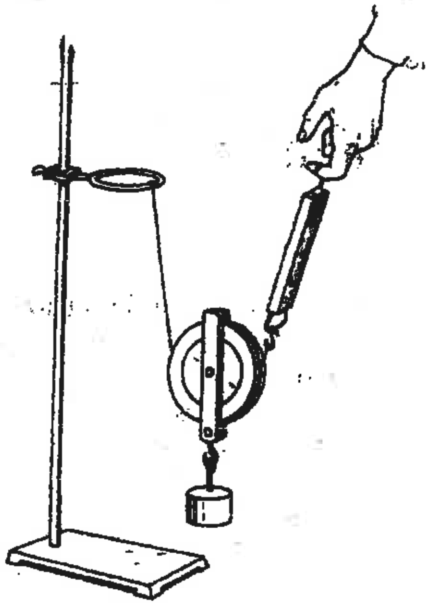


Figure 2

4. Set up the pulley system shown in Figures 3

USE THE LONG STRING.

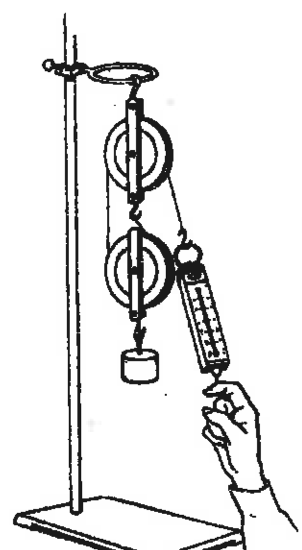


Figure 3

5. Set up a block and tackle with a double fixed and a double movable pulley. See the example on the front desk to help you set this up.

Name ______________________________ Class ______________ Date ____________

Observations

DATA TABLE

Pulley Arrangements	Resistance (R)	Effort (E)	Mechanical Advantage (R ÷ E)
Single fixed			
Single movable			
Single fixed and single movable			
[redacted]	[redacted]	[redacted]	[redacted]
Double fixed and double movable			

Analysis and Conclusions

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

____

____

____

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

____

____

3. How does the type of pulley or pulley system affect the mechanical advantage?

____

____

____