Name ______________________________ Date _______________

Experiment
30

First-Class Levers

A *lever* is a simple machine used to make work easier. It consists of a long, rigid bar with a support that allows the bar to pivot. The point where the bar pivots is the *fulcrum*. There are three classes of levers—first, second, and third. In this experiment, you will examine first-class levers. Crowbars and scissors are examples of first-class levers. A lever can help you move an object by increasing the force you exert. Mechanical advantage (MA) is a value that tells the number of times a machine increases an applied force. You will use a Force Sensor to measure resistance force and effort force (in newtons). You will then use this information to calculate the mechanical advantage of each lever.

OBJECTIVES

In this experiment, you will

- measure force.
- calculate actual mechanical advantage (AMA).
- calculate ideal mechanical advantage (IMA).
- calculate percent difference.
- make conclusions about levers.

MATERIALS

LabPro or CBL 2 interface	500 g mass
TI graphing calculator	loop of string
DataMate program	meter stick
Vernier Force Sensor	fulcrum

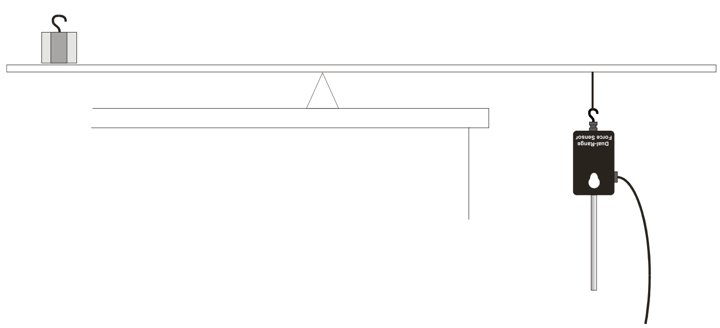

Figure 1

PROCEDURE

1. Plug the Force Sensor into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI graphing calculator to the interface. Firmly press in the cable ends. If you are using a Dual-Range Force Sensor, set the range switch to 10 N.

2. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

3. Set up the calculator and interface for the Force Sensor.
   a. Select SETUP from the main screen.
   b. If the calculator displays the correct Force Sensor in CH 1, proceed directly to Step 4. If it does not, continue with this step to set up your sensor manually.
   c. Press ENTER to select CH 1.
   d. Select FORCE from the SELECT SENSOR menu.
   e. Select the correct Force Sensor and setting from the FORCE menu.

4. Zero the Force Sensor with its hook pointing down.
   a. Attach a loop of string to the hook of the Force Sensor.
   b. Hold the Force Sensor in a vertical position with its hook pointing down. Make sure the hook and string are not touching anything.
   c. Select ZERO from the SETUP menu.
   d. Select CH1-FORCE (N) from the SELECT CHANNEL menu.
   e. Press ENTER to zero the Force Sensor.

5. To measure the resistance force (F_r) for Trials 1, 2 and 3, hang the mass that will be used as the resistance from the Force Sensor. After the reading has stabilized, record this force reading in the Resistance Force blanks for Trials 1, 2 and 3.

6. Zero the Force Sensor with its hook pointing up.
   a. Remove the loop of string from the Force Sensor.
   b. Hold the Force Sensor in a vertical position with its hook pointing up. Rest the tip of its handle on the tabletop.
   c. Select SETUP from the main screen.
   d. Select ZERO.
   e. Select CH1-FORCE (N) from the SELECT CHANNEL menu.
   f. Press ENTER to zero the Force Sensor.

7. Place a fulcrum near the edge of your lab table. Balance the middle of a meter stick on the fulcrum as shown in Figure 1.

8. Place the center of the mass that is acting as your resistance force on the 90-cm line (D_r = 40 cm).

9. Attach the loop of string to the hook of the Force Sensor. Loop the string over the meter stick at the 10 cm line (D_e = 40 cm) as shown in Figure 1. With the fulcrum between the effort and the resistance, this is a first-class lever. Pull down with the Force Sensor until the meter stick is balanced. Record the force needed to balance the meter stick. This is the effort force (F_e).

10. Place the center of the mass acting as the resistance force on the 70 cm line (D_r = 20 cm). The position of the effort force (Force Sensor) should not change. Repeat Step 9.

11. Now move the center of the resistance force to the 60 cm line (D_r = 10 cm). The position of the Force Sensor should not change. Repeat Step 9.

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DATA

Trial	Resistance distance (cm)	Resistance force (N)	Effort distance (cm)	Effort force (N)
1	40		40	
2	20		40	
3	10		40	

PROCESSING THE DATA

1. Calculate the actual mechanical advantage for each of your three trials using the formula

$$AMA = F_r / F_e$$

where *AMA* = actual mechanical advantage, F_r = resistance force, and F_e = effort force. Record results in the table that follows Question 3.

2. Ideal mechanical advantage is determined by the formula

$$IMA = D_e / D_r$$

where *IMA* = ideal mechanical advantage, D_e = effort distance, and D_r = resistance distance. Calculate the ideal mechanical advantage of the levers you tested. Record results in the table that follows Question 3.

3. Calculate the percent difference between IMA and AMA for each of your trials using the formula

$$\% \text{ Difference} = \frac{\text{Difference between IMA and AMA}}{\text{IMA}} \times 100$$

Record the results in the following table.

Trial	AMA	IMA	Percent difference
1			
2			
3			

4. What happened to the mechanical advantage as you shortened the resistance distance?

5. How did moving the resistance force closer to the fulcrum affect effort needed to balance it?

6. What was the mechanical advantage of the first lever you tested? Why would a lever like this be used?

7. Are your values for percent difference between IMA and AMA large or small?

8. Describe some factors that might contribute to the difference between IMA and AMA in this experiment.

EXTENSION

1. Design and perform an experiment to test second-class and third-class levers. Include a data table, calculations, and conclusions.