SCIENCE

NAME: PERIOD: DATE:

Mechanical Advantage of Levers Lab

Intro: A *lever* is a kind of simple machine. The *fulcrum* of the lever is the nonmoving point about which the lever rotates. The res*i*stance is the force the lever lifts. The *effort* is the force applied to the lever by the user. *Mechanical advantage* equals resistance force divided by effort force. It is the factor by which a lever multiplies effort put into it. The *resistance* is the force that the lever applies to the load.

Problem: How does the position of the fulcrum, resistance force, and effort force affect the mechanical advantage of first, second, and third class levers?

Materials:

Wedge-shaped block of wood (10 cm high)
Rigid meter stick
500 g mass (4.9 N weight)
Wire clamps (2)
Newton spring scale

Purpose: In this lab you will study all three classes of levers. By changing the distances between fulcrum, resistance force and effort force you will observe the effects on mechanical advantage.

Procedure – First Class Lever:

1. Work with a partner. Set up a first class lever as shown in Figure 1
   a. Place a clamp on the meter stick at the 50 cm mark to serve as the fulcrum. Position this clamp on the stand.
   b. Hang the 500 g mass on another clamp at the 10 cm mark, 40 cm from the fulcrum. **This mass serves as the resistance force**.
   c. Attach another clamp at the other end of the stick at the 90 cm mark – which will be 40 cm from the fulcrum. Hang the spring scale from this clamp. **The spring scale serves as the effort force**.
   d. Pull down on the scale to lift the weight. Read the effort force from the scale.
   e. Record the distance from the fulcrum to the resistance. Record the distance from the fulcrum to the spring scale. Record the effort force.
2. Leaving the resistance weight and the scale at the same positions, move the fulcrum clamp to the <u>40 cm mark</u>. Record the distance from the new position of the fulcrum to both the resistance force and the spring scale. Pull down on the scale to lift the mass. Record the effort force.
3. Repeat step 2 moving the fulcrum clamp to the <u>60 cm mark</u>.
4. **Using the mechanical advantage formula with F_e & F_r**, calculate the mechanical advantages for the first class lever in each of the positions and record.

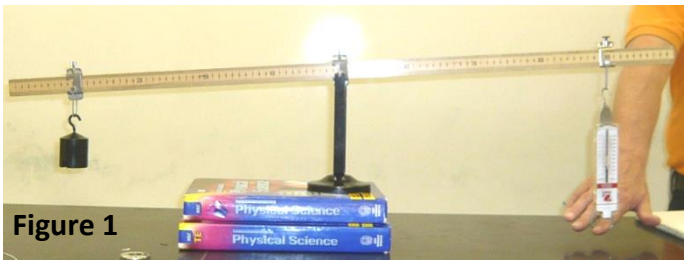

Figure 1

First Class Lever Data Table				
Fulcrum Position (cm)	**Distance from Fulcrum to Resistance (cm)**	**Distance from Effort to Fulcrum (cm)**	**Effort Force (N)**	**Mechanical Advantage**

Procedure – Second Class Lever


Figure 2

1. Make a second class lever as shown in Figure 2.
   a. Place the fulcrum clamp on the 10 cm mark of the meter stick and place it on the stand.
   b. Hang the 500 g mass on a clamp at the 50 cm mark. Attach the scale to a clamp at the 90 cm mark. Pull up on the spring scale to raise the stick. While you do so, hold the clamp down on the fulcrum so that it does not rise or slide (see fig. 2).
   c. Record the distance from the fulcrum to the resistance weight. Record the distance from the fulcrum to the scale. Record the effort force from the scale.
2. Leaving the fulcrum and the scale where they were in the previous step, move the <u>resistance weight clamp to the 30 cm mark</u>. Pull up on the scale to lift the mass. Record the effort force and both distances to the fulcrum.
3. Repeat the previous step but move the <u>resistance weight clamp to the 20 cm mark</u>.
4. **Using the mechanical advantage formula with forces**, calculate the mechanical advantages for the first class lever in each of the positions and record.

Second Class Lever Data Table				
Fulcrum Position (cm)	**Distance from Fulcrum to Resistance (cm)**	**Distance from Effort to Fulcrum (cm)**	**Effort Force (N)**	**Mechanical Advantage**

Procedure – Third Class Lever

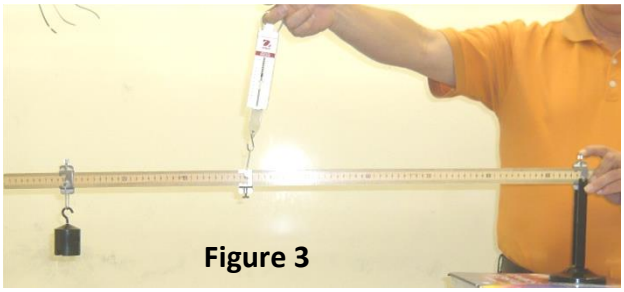
Figure 3

1. Make a third class lever as shown in Figure 3.
   a. Place the fulcrum clamp at the 90 cm mark.
   b. Attach the scale at the 50 cm mark. Attach the 500 g mass at the 10 cm mark.
   c. Pull up on the scale to raise the stick and resistance weight. While doing so you will again need to hold the clamp down on the stand to keep it in place (see fig. 3).
   d. Record the effort force from the scale and the distances from the fulcrum to both the resistance force and the scale.
2. Leave the fulcrum and resistance weight where they were in the previous step, <u>move the spring scale to the 30 cm mark</u>. Pull up on the scale to lift the weight. Record the effort force and both distances to the fulcrum
3. Repeat the previous step but <u>move the scale to the 20 cm mark</u>.
4. **Using the mechanical advantage formula with forces**, calculate the mechanical advantages for the first class lever in each of the positions and record.

DATA TABLE ON NEXT PAGE

Third Class Lever Data Table				
Fulcrum Position (cm)	**Distance from Fulcrum to Resistance (cm)**	**Distance from Effort to Fulcrum (cm)**	**Effort Force (N)**	**Mechanical Advantage**

Questions:

1. For the first class lever, did the effort force become larger or smaller when you moved the fulcrum closer to the resistance force?

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2. For the second class lever, did the effort force become larger or smaller when you moved the resistance force closer to the fulcrum?

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3. For the third class lever, did the effort force become larger or smaller when you moved the effort force closer to the resistance force?

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4. For the first class lever, how does moving the fulcrum affect the mechanical advantage?

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5. For the second class lever, how does moving the resistance force affect the mechanical advantage? What would happen to the mechanical advantage if the effort force was moved closer to the resistance force?

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6. How do third class levers differ from the other two classes? Can you think of a benefit of using third class levers?

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7. Make a general statement about the way to increase mechanical advantage that applies to all classes of levers.

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8. Imagine that you are attempting to pry up a boulder using a pole as a lever and a small stone as a fulcrum. State which class of lever this would be and how you can tell. Would you choose a long pole or a short one for the task? In order to make the easiest possible effort force, would you place the small stone close to the boulder or farther away from the boulder – explain your answer using mechanical advantage.

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9. Imagine that you are trying to crack an especially tough nut and have a choice of two similar, standard design nutcrackers that have two hinged handles. One nutcracker has longer handles than the other one. State which class of lever the nutcrackers are and how you can tell. Which nutcracker would you use and why? Where would you place the nut relative to the arms & the hinges to make the easiest possible effort force – explain your answer using mechanical advantage?

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10. When you lift something by moving your arm with a curling motion your forearm acts as a lever. Your elbow is the fulcrum. Your biceps muscle applies the effort force at its point of attachment to your lower arm, just below the elbow. The resistance force is the object you hold in your hand. What type of lever is your arm? What benefit is there to this arrangement?

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