Trust | Deliver | Learn

SIMPLE MACHINES : LEVER

CAT NO. WDSM18

Experiment Guide

GENERAL BACKGROUND :

There are six simple machines that all other machines are made out of. Even complex machines like an automobile really consist of simple machines that all convert energy in order to do work. Machines are used to make work easier. Here work is defined as a force applied over a given distance. The force applied and the distance traveled must be in the same direction.

Simple machines can either change the direction the force is applied, or increase the mechanical advantage by doing the same amount of work over a longer distance and therefore decreasing the amount of force needed.

There are six simple machines that include levers, pulleys, inclined planes, wedges, wheel and axels, and screws. Compound machines have two or more simple machines that when used together make work easier.

Mechanical advantage is a way of measuring how much easier it is to do work or how much less force is required. Written as a formula:

$$\text{Mechanical Advantage} = \frac{\text{Output force (load)}}{\text{Input force (effort)}}$$

The load is the amount of force or weight that is being lifted.

The effort is the amount of force or weight being applied to the rope in order to move the load.

A pulley is a variation of a wheel and axel in which a rope or cord is stretched over a wheel to make it rotate as the rope is pulled. Pulleys are used to raise and lower flags, on oil derricks, to raise, lower, and adjust sails on a sailboat, and to pull open or close curtains. A single pulley can change the direction that a force is needed to be applied in order to make doing work more convenient. A combination of several pulleys can make it easier to do work, by applying a smaller force over a larger distance mechanical advantage is gained.

Levers are in use when a long stiff object, like a post or board rest on a fulcrum. The fulcrum is simply the pivot point on which the board or post rests. The pivot point does not undergo any translational motion (it doesn't move). The lever lifts a load by applying an effort force. The arrangement of the effort, load and fulcrum determines the “class” of levers. There are three classes of levers.

In first class levers as shown in diagram 1:

- the fulcrum is positioned between the effort and the load
- the effort is smaller than the load

- the effort moves further than the load
- the lever can be considered force magnifier

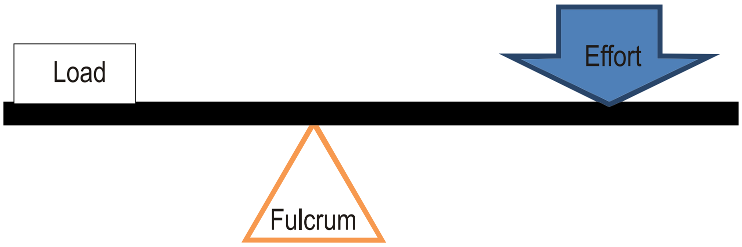

Diagram 1

Examples of class one levers are a teeter totter or see-saw, a catapult, scissors, or a crowbar.

In class two levers as shown in diagram 2:

- the effort and the load are positioned on the same side of the fulcrum but applied in opposite directions
- the load lies between the effort and the fulcrum
- the effort is smaller than the load
- the effort moves further than the load
- the lever can be considered a force magnifier

Class two levers have the load in the middle and the fulcrum on the end and effort is applied on the opposite side of the fulcrum as shown in diagram 2. Examples of class two levers are wheel barrows, shovels and nutcrackers.

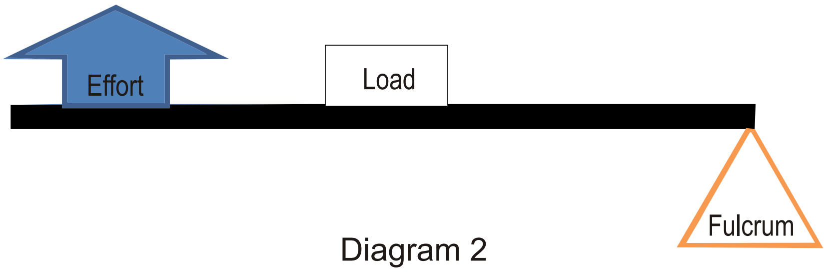

Diagram 2

In class 3 levers as shown in diagram 3:

- the effort lies between the load and the fulcrum
- the effort is greater than the load
- the load moves further than the effort
- the lever can be considered a distance magnifier

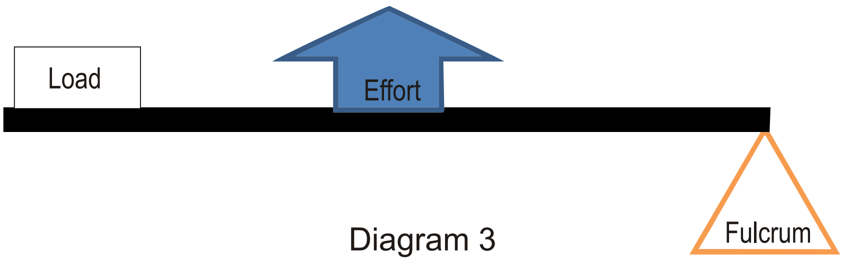

Diagram 3

Class three levers have the load on one end of the post, the fulcrum on the opposite end, and the effort is applied to the middle as shown in diagram 3. A fishing pole or tweezers or your forearm are good examples of class three levers.

The effort force applied to a lever can be calculated by a simple formula:

$$\left[\text{Force applied or weight of the load}\right]\left[\text{Distance from the center of the load to the fulcrum}\right] = \left[\text{Force applied by the effort}\right]\left[\text{Distance from the center of the effort to the fulcrum}\right]$$

$$F_l \times d_l = F_e \times d_e$$

$F_l \times d_l$ is also called the torque. Torque is the force applied to an object to get it to undergo rotational motion.

If we rearrange this equation we get:

$$\frac{F_l}{F_e} = \frac{d_e}{d_l}$$

This means that if the distance between the effort and the fulcrum is smaller than the distance between the load and the fulcrum, we will be able to apply less force to lift a heavier object. This is true in class 1 and class 2 levers.

A wedge is a simple machine that changes the direction of a force. The force applied is usually perpendicular to the force acting on the object. Examples of wedges are door stops, nails, axes, teeth (incisors, not molars), pins, a chisel.

Wheels and axles increase mechanical advantage by covering a longer distance using less force. The larger the wheel the greater the mechanical advantage. When bikes were first invented, many inventors tried to increase the mechanical advantage of the bike by increasing the size of the wheel that was being rotated. Although this did allow for longer distances to be covered by one rotation of the wheel, it also make the bike difficult to pedal.

As a wheel turns the distance traveled by the one rotation of the wheel is directly proportional to the diameter of the wheel. For the penny farthing bike one rotation of the pedal equals one rotation of the bike's wheel. However the distance covered by the person's foot is much smaller than the distance covered by the bikes wheel. Examples of wheels and axles include bike tires, car tires, windmills, and steering wheels.

Inclined planes also increase mechanical advantage by increasing the distance traveled and decreasing the amount of force applied. Examples of inclined planes include ramps, hills, ladders, stairs and the backs of dump trucks.

Screws are really just inclined planes wrapped around a post as shown in diagram 4. Examples of common screws are screw top jar lids, drill bits, meat grinders, corkscrews, swivel stools, and of course, screws.

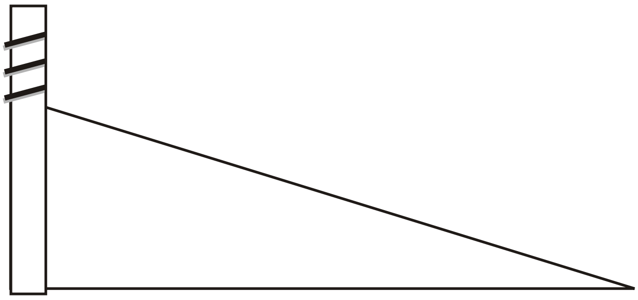

Diagram 4

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Lever	1
Fulcrum on a base	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Heavy objects such as text books	1
Picture of levers from photos or magazines	20

ACTIVITY 1: CAN YOU LIFT IT? (TEACHER ANSWERS)

Students may come to your classroom with some practical experience on levers (perhaps flinging mashed potatoes off of a spoon, or helping Mom and Dad dig weeds out of a garden.) This lever is so simple that it can intuitively be used to discover some of the basic properties of a lever as well as help students use some terms to scientifically describe what they are seeing and using.

Have students try the lever out by lifting something heavy and flat, a textbook works well. Have them change the position of the lever and note how this changes the force they need to apply to lift the text book. Be sure to give students enough table space as objects will easily slide off the end of the lever.

PROCEDURE:

1. Place the metal pin into one of the three notches and place a book or some other flat heavy object on the tapered (pointed) side of the lever.

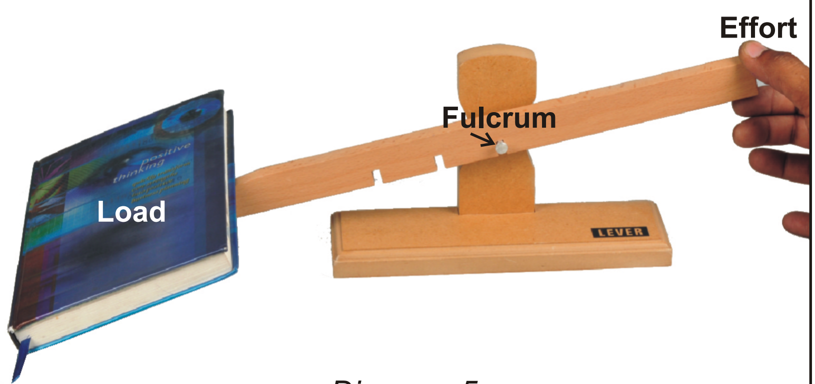

Diagram 5

2. Press down on the very end of the lever as shown in diagram 5 and observe how easy or difficult it is to lift the object.

3. Repeat this for all three notches and then determine with your partners if there was any difference between the three positions. If there was a difference, what was it you noticed?

   (Students should notice that it is easier (requires less force) to lift the book when the distance between the post and the load is the shortest.)

4. Finish this sentence: As the distance between my hand and the metal pin increases, the force needed to lift the book *decreases*.

5. A lever is basically a stiff post or board that rotates on a single stationary point. This single stationary point is called a fulcrum. Identify the fulcrum in diagram and label it.

6. The object that is being lifted is called the load. Identify and label the load in diagram 5.

7. The force being applied to move the object is called the effort. In diagram 5, label object applying the effort with the word "effort".

8. Torque is the amount of force applied to rotate an object times the distance that object is from the pivot point (in this case the fulcrum.) This helps explain why we are able to do the same amount of work with less force using a lever. Look at the lever in diagram 6 which shows the lever set up so it is easiest to do work.

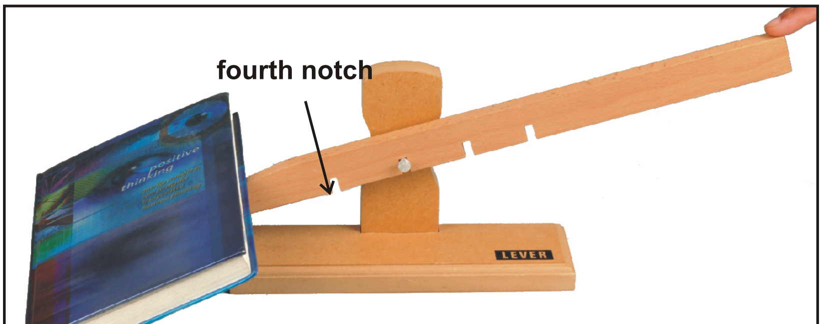

Diagram 6

9. Does it require more force to lift the book with or without the lever?
   (It requires more force to lift the book without the lever.)

10. Which is greater, the distance between the fulcrum and the effort, or the fulcrum and the load?

    (The distance between the fulcrum and the load is smaller than the distance between the fulcrum and the effort.)

11. The amount of torque applied by your hand is equal to the amount of torque acting on the other end of the lever, therefore a big force is being applied over a little distance on one side of the lever and a little force is being applied over bigger distance on the other side of the lever. Write an equation using "F" as the big force and "f" as the little force, "D" is the bigger distance and "d" is the smaller distance where the left hand side of the equation represents the torque applied by your hand and the right hand side of the equation represents the torque applied by the load.

$$f \times D = F \times d$$

12. Using your equation above. If you made the distance between the fulcrum and the load longer, would this make it easier or harder to do work? (Easier means using less force, harder means using more force.)

    (It would make it harder to do work.)

13. Draw in a fourth notch on diagram 6 showing where you would place a notch to make your work even easier to do. Explain why you would put your notch there in terms force and distance.

    (Anywhere between the fulcrum and the book the notch can be placed. Students should say something along the lines of. A notch placed here would allow us to move the fulcrum and make the distance between the fulcrum and the hand greater, therefore requiring less force to lift the book.)

NAME:______________________________________ DATE:______________

ACTIVITY 1: CAN YOU LIFT IT?

PROCEDURE:

1. Place the metal pin into one of the three notches and place a book or some other flat heavy object on the tapered (pointed) side of the lever.

2. Press down on the very end of the lever as shown in diagram 5 and observe how easy or difficult it is to lift the object.

3. Repeat this for all three notches and then determine with your partners if there was any difference between the three positions. If there was a difference, what was it you noticed?

4. Finish this sentence: As the distance between my hand and the metal pin increases, the force needed to lift the book ______________.

5. A lever is basically a stiff post or board that rotates on a single stationary point. This single stationary point is called a fulcrum. Identify the fulcrum in diagram and label it.

6. The object that is being lifted is called the load. Identify and label the load in diagram 5.

Diagram 5

7. The force being applied to move the object is called the effort. In diagram 5, label object applying the effort with the word “effort”.

8. Torque is the amount of force applied to rotate an object, times the distance that object is from the pivot point (in this case the fulcrum.) This helps explain why we are able to do the same amount of work with less force using a lever. Look at the lever in diagram 6 which shows the lever set up so it is easiest to do work.

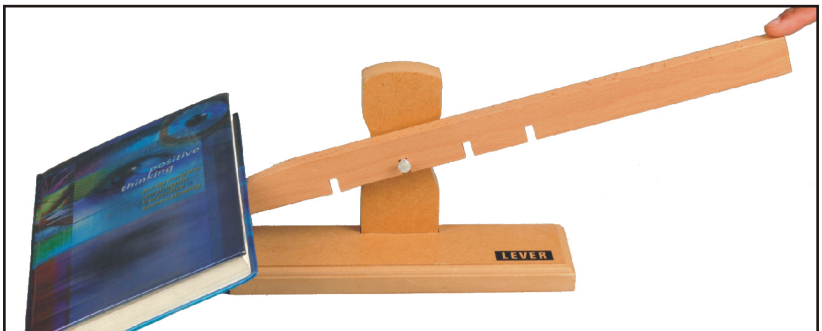

Diagram 6

9. Does it require more force to lift the book with or without the lever?

____

____

10. Which is greater, the distance between the fulcrum and the effort, or the fulcrum and the load?

____

____

____

11. The amount of torque applied by your hand is equal to the amount of torque acting on the other end of the lever, therefore a big force is being applied over a little distance on one side of the lever and a little force is being applied over bigger distance on the other side of the lever. Write an equation using "F" as the big force and "f" as the little force, "D" is the bigger distance and "d" is the smaller distance where the left hand side of the equation represents the torque applied by your hand and the right hand side of the equation represents the torque applied by the load.

____

12. Using your equation above. If you made the distance between the fulcrum and the load longer, would this make it easier or harder to do work? (Easier means using less force, harder means using more force.)

____

____

13. Draw in a fourth notch on diagram 6 showing where you would place a notch to make your work even easier to do. Explain why you would put your notch there in terms force and distance.

____

____

____

ACTIVITY 2: TYPES OF LEVERS (TEACHER ANSWERS)

1. In activity 1, the lever was set up as a first class, second class or third class lever?
   <u>*(A first class lever)*</u>

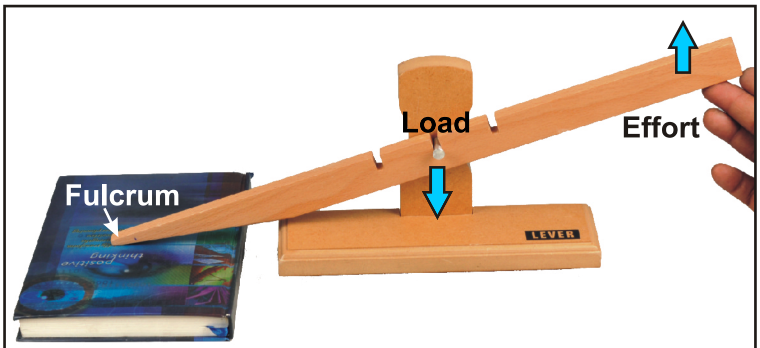

Diagram 7

2. Diagram 7 shows what type of lever?
   <u>*(A second class lever)*</u>
3. Label the fulcrum, the effort and the load in diagram 7.
4. Draw an arrow representing the direction of the force applied to the lever by the effort and the load in diagram 7.

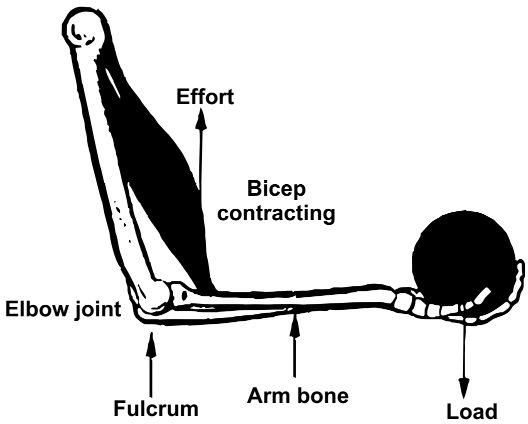

Diagram 8

5. Diagram 8 shows a picture of someone raising his forearm using his muscles. The muscle that allows you to raise your arm is called your bicep. As the bicep contracts, your forearm is pulled toward your shoulder. Diagram 8 shows approximately where your muscle is attached to your forearm bones. Label the fulcrum, effort and load in diagram 8.
6. Draw an arrow showing the direction of the effort force and the load.
7. Diagram 8 shows what type of lever? <u>*(A third class lever)*</u>
8. Find or take a picture of three objects you see around you that are levers and label the load, fulcrum and effort in each picture. Determine if the lever is a first, second or third class lever.
   <u>*(Teachers may want to have some pre-made pictures from magazines cut out for this activity or have the students find their own pictures. This can be done as a class, as a homework assignment or individually and have students share and discuss their ideas as a class. You may want to discuss different classes of levers, and how the arrangement of the load, effort and fulcrum determine what class lever is being used in each situation.)*</u>

NAME:_______________________________________ DATE:_______________

ACTIVITY 2 : TYPES OF LEVERS

First class levers as shown in diagram 1:

- the fulcrum is positioned between the effort and the load
- the effort is smaller than the load and the effort moves further than the load
- the lever can be considered force magnifier

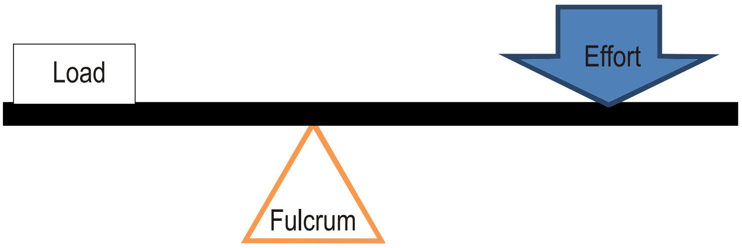

Diagram 1

Class two levers as shown in diagram 2:

- the effort and the load are positioned on the same side of the fulcrum but applied in opposite directions
- the load lies between the effort and the fulcrum
- the effort is smaller than the load and the effort moves further than the load
- the lever can be considered force magnifier

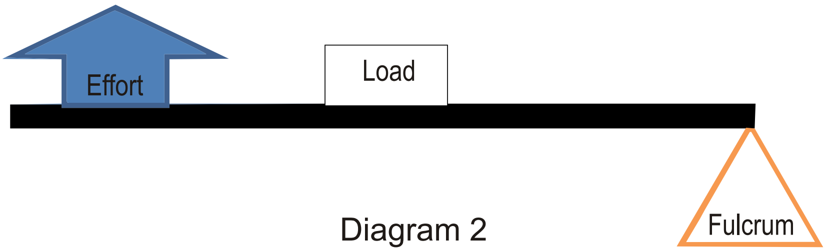

Diagram 2

Class three levers as shown in diagram 3:

- the effort lies between the load and the fulcrum
- the effort is greater than the load
- the load moves further than the effort
- the lever can be considered distance magnifier

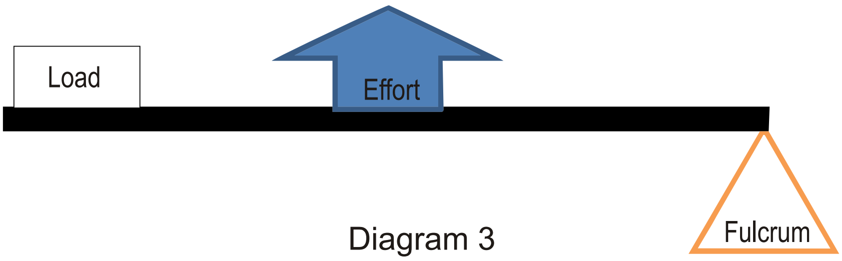

Diagram 3

1. In activity 1, the lever was set up as a first class, second class or third class lever?

____

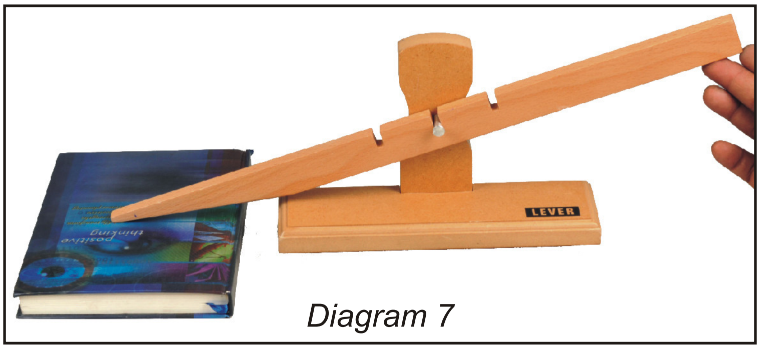

Diagram 7

2. Diagram 7 shows what type of lever?

____

3. Label the fulcrum, the effort and the load in diagram 7.

4. Draw an arrow representing the direction of the force applied to the lever by the effort and the load in diagram 7.

5. Diagram 8 shows a picture of someone raising their forearm using their muscles. The muscle that allows you to raise your arm is called your bicep. As the bicep contracts, your forearm is pulled toward your shoulder. Diagram 8 shows approximately how your muscle is attached to your forearm bones. Label the fulcrum, effort and load in diagram 8.

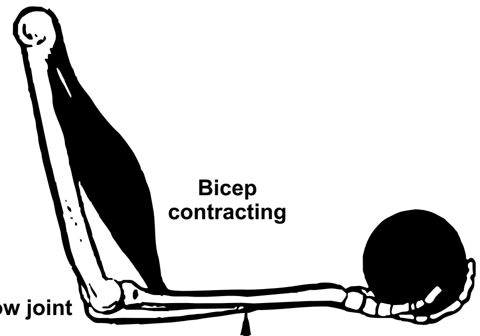

Diagram 8

6. Draw an arrow showing the direction of the effort force and the load in diagram 8.

7. Diagram 8 shows what type of lever?

____

8. Find or take a picture of three objects you see around you that are levers and label the load, fulcrum and effort in each picture. Determine if the lever is a first, second or third class lever.

Manufactured by :
eisco
Trust | Deliver | Learn
www.eiscolabs.com

U.S. Distributor:
Eisco Scientific
788 Old Dutch Road, Victor, NY 14564
Website: www.eiscolabs.com