Mechanical Advantage of Levers	Grade 8 Systems in Action

Lesson Plan	Safety Notes	Choose weights that could reasonably be lifted by a ruler or paint stick without breaking it!

Description

Learn about the three classes of lever and investigate how they help us do work by experimenting with your own levers at home.

Materials

- 2 rulers (at least 1 that is not bendy) or 1 ruler and 1 wooden paint stir stick
- Pencil
- 2 plastic cups or containers (should be the same)
- Tape
- Many identical small objects to serve as small weights (ex: coins, buttons, legos, marbles)- something pourable like sand, lentils, or sugar may also work but might make a mess
- Mechanical Advantage of Levers handout

Science Background

A lever is a type of simple machine made up of a rigid bar that can turn freely around a fixed point. Levers help make work easier and are all made up of four parts: the beam, the fulcrum, the effort, and the load.

Levers can be divided into three classes depending on the location of the effort, load and fulcrum along the beam.

Figure 1: Parts of a Lever

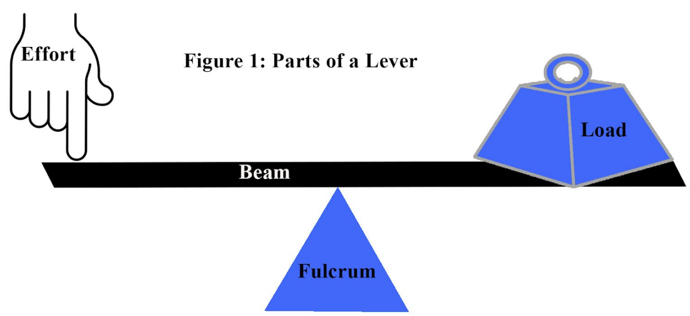
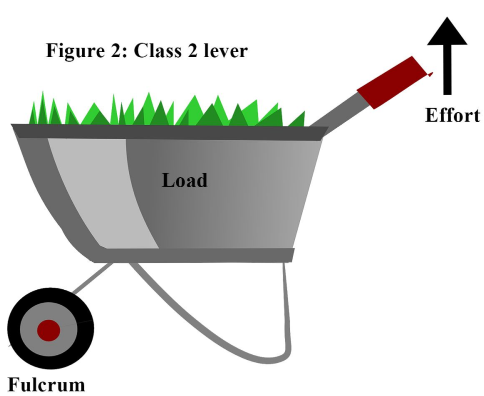


Figure 2: Class 2 lever



In Class 1 levers the fulcrum is located between the effort and the load (like in figure 1). A good example of a Class 1 lever you may be familiar with is a see-saw.

In Class 2 levers the load is between the effort and the fulcrum, like the wheelbarrow in figure 2.

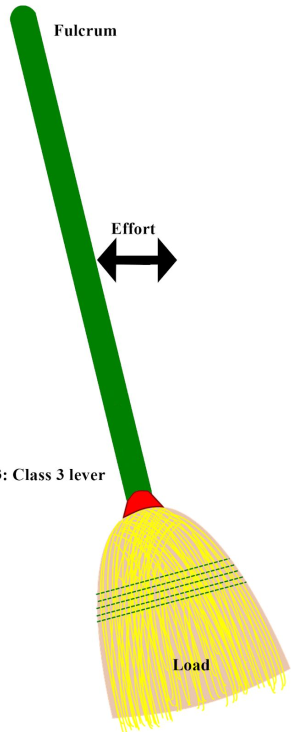


Figure 3: Class 3 lever

In Class 3 levers the effort is between the load and the fulcrum, like using a broom to sweep (figure 3).

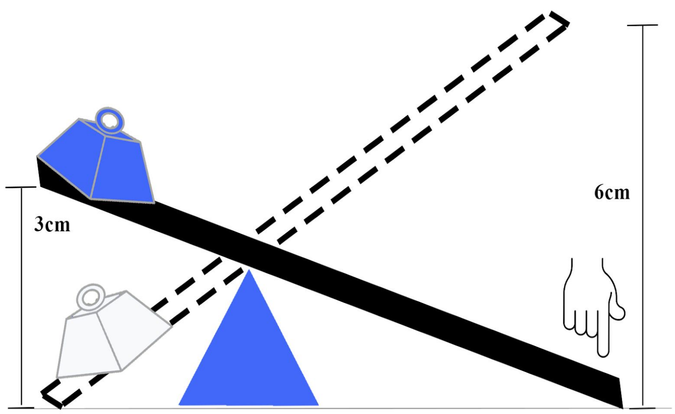
Levers help make work easier by giving us a mechanical advantage. This advantage is either a distance advantage or a force advantage. A distance advantage allows us to move our load a farther distance than the distance of our effort. An example of this is how the head of a broom travels a much larger distance over the floor than our hand (the effort) does. A force advantage allows the output force acting on the load to be greater than the input force given by the effort. This makes lifting something heavy feel easier.

How we build our levers impacts what kind of advantage we get. Let's explore how different levers make work easier!

Activity Procedure

Part 1: Exploring Distance Advantage

1. Build a Class 1 lever using a ruler or paint stick as the beam and pencil as the fulcrum.
2. Tape a cup to the beam where you will want to place your load and then put some of your weights in the cup.
3. Use the worksheet to compare the load distance to the effort distance. In this experiment effort distance will be the distance that is pushed down when you provide effort. The load distance will be how far off the table the part of the lever with the load moves when you provide effort. For example, for the lever to the right, the effort distance is 6cm and the load distance is 3cm.



4. Repeat step 3 two more times with your fulcrum placed in a slightly different spot each time (still creating a Class 1 lever) and record your measurements.

5. Calculate the distance ratio of your lever.
   The distance ratio is the effort distance compared to the load distance. Following the example lever above, the distance ratio would be 6:3 which could be simplified to 3:1.
6. Repeat steps 1 to 4 for Class 2 and 3 levers. Unlike in Class 1 levers where you measured the effort distance before applying the effort, you will need to measure the effort distance and load distance after applying the effort. For Class 2 levers be careful not to lift your load so far that your beam lifts off your fulcrum! For Class 3 levers you might find it helpful to get a sibling or parent hold the beam down on the fulcrum while you lift.
7. Notice which levers provided a distance advantage (the load distance is greater than the effort distance).

Part 2: Exploring Force Advantage

1. Build a Class 1 lever such as the one you built in Part 1 but this time tape one cup to each end of the beam.
2. Add a set amount of small weights to the load side of the lever (e.g 15 nickels or 6 tablespoons of lentils). This is the load that is being lifted by the lever.
3. Using the cup on the other side of the lever, add small weights until the load is lifted. The weight being added is the effort weight. You can use the distance ratio to help you predict what your effort weight will be. The force ratio (effort force:load force) of a lever is the opposite of its distance ratio. In our experiment, weight can be substituted for force. For example, if the distance ratio of a lever is 2:1 the force ratio is 1:2. If the load force on this example lever was 10 pennies then the predicted effort force would be 5 pennies (1:2 = effort force:10, 2x5=10 so 1x5=effort force, so effort force=5).
4. Use the worksheet to compare how much weight (e.g. how many nickels or how many tablespoons of lentils) you have to add to the cup on the effort arm of the beam to get the load to move. Repeat the test 3 times with the fulcrum in different positions (still a Class 1 lever).
5. Notice how the placement of the fulcrum impacts how much weight (how much effort) you have to apply to lift the load. Also notice if your predicted effort weights were accurate. If the actual effort weight was different than your predictions what do you think caused this?

Debrief

As observed from the experiments, not all levers provide the same type of mechanical advantage. Some provide a distance advantage, while some provide a force advantage. This is why we choose different kinds of levers for different tasks.

In part 2 of the experiment did you notice that the closer to the load your fulcrum was located the less weight (less effort) you had to apply to lift the load? This is because the amount of force applied to the effort side of the lever is equal to the amount of force that then acts on the load side. The bigger the

distance from the fulcrum to the load, the bigger area that the force (effort) has to be spread across. This in turn means that you have to apply more force (effort) to the effort side of the lever to reach the tipping point.
In part 2 of the experiment were your predictions for the effort weight accurate? If the actual effort weight differed from your predictions it is likely because your measurements are not exact. For example if your weights were buttons that are almost the same size but not quite or that are made out of different kinds of materials then the 5 buttons that make up your load might not weigh the same as 5 buttons you add as your effort. The closer to identical all your weights are the more accurate your predictions will be!

Handout

Distance Advantage

CLASS 1 LEVER

Effort distance (cm)	**Load distance (cm)**	**Distance Ratio (Effort Distance:Load Distance)**

CLASS 2 LEVER

Effort distance (cm)	**Load distance (cm)**	**Distance Ratio (Effort Distance:Load Distance)**

CLASS 3 LEVER

Effort distance (cm)	**Load distance (cm)**	**Distance Ratio (Effort Distance:Load Distance)**

Force Advantage

Effort distance (cm)	Load distance (cm)	Distance Ratio (Effort Distance: Load Distance)	Effort Weight (Predicted)	Effort Weight (Actual)