Lever Lifting

Simple machines can help us accomplish a task by trading force and distance. As the distance we apply a force goes up, we need to put in less force to do the same thing. A lever is a type of simple machine, and in this activity, students will experiment with the connection between force and distance.

Materials

- 12-inch ruler
- (optional) a second ruler for making measurements
- 2 small paper cups (Dixie cups would work)
- Tape
- Weights (such as marbles, steel nuts, or dead AA batteries)
- Dry erase marker, or some other cylinder to use as a fulcrum
- Table (Page 4)

Making the Lever

The students will be making a lever out of the ruler and thick marker. The marker will be the fulcrum, and the ruler will be the bar. Start off by placing the marker underneath the ruler at the 6-inch line. The ruler should be able to easily tilt back and forth.

In order to do tests with this lever, we will tape one paper cup on each end of the ruler (perhaps around 1-inch and 11-inches), facing up. Have them write the letter L (Load) on the cup near the 1-inch mark. This will act as our load, what we are trying to lift. Mark the other cup with the letter E (Effort). Now to experiment with the lever, we can put some number of weights in the load cup and see how many weights we have to add to the effort cup to lift it up. By moving where the fulcrum is, the students can test out the effects of changing a lever.
Suggestions for Using the Lever

Starting with the fulcrum at the 6-inch line, have the students make predictions about how many weights they will need to add to the E cup to lift up the L cup. It is good to start with a substantial amount of weight in the L cup, such as a battery. Once the students have done the test, have them repeat it with more weight in the L cup. Then have them move the fulcrum to the 4-inch line (close to the load), and finally the 8-inch line (far from the load). Each time, make sure they first fill the load cup, then make predictions about how much they will need to add to the effort cup.

The students should notice a connection, the closer the load is to the fulcrum, the less force they need on the far end to lift it. The heavier end has to be closer to the fulcrum to balance.

The table on page four is an example of a sheet you can use to have them record their data. If the class is familiar with graphing, you can collect the data from all the groups and graph it on the board.

As the last part of the experiment, just as we lifted a teacher during the Motion: Forces and Work program, give the students an equally big challenge. For instance, lift a load of nine weights using just one. Before you give the students the nine weights, have each group explain where the fulcrum should go and why they think that. Then let them test to see if they are right.

Explanation

Talking about how simple machines work, it is often said they trade force and distance. If the force pushing down on the load end of a lever is twice the force on the effort end, it will only balance if the force on the effort end is twice as far away from the fulcrum. If the force and distance multiply to the same number for each end, the lever should balance. The exact quantitative connection is above what the students need to know, but they should at least understand the general idea that the heavier weight should be placed closer to the fulcrum.
For this experiment, as we move the fulcrum, there is more weight just from the ruler on one end. Make sure the weights you are adding to the cups weigh enough to overcome this.

**Math Connection**

If you’d like to tie in the math explicitly, the main equation here is: \( W = F \times D \).

The amount of work you are putting into (or getting out of) a simple machine is the force of the push times the distance the push is applied. The distance in this equation is NOT the distance along the ruler that is used to make the lever. The distance along the ruler is just a convenient way to get your students to notice the pattern and make predictions.

To properly use this equation, though, you should use the distance that the weights move up and down as the lever tilts. A second ruler can be used for this. You can have your students multiply the amount of weights by the distance that side can tilt and have them see if they can notice a trend.

When the force on one end times its distance is equal to the force on the other end times its distance, the lever will just balance. That is when it reaches the tipping point.
<table>
<thead>
<tr>
<th>Where is the fulcrum?</th>
<th>How far is the L cup from the fulcrum?</th>
<th>How far is the E cup from the fulcrum?</th>
<th>How many weights are in the L cup?</th>
<th>Predict how many you need in the E cup</th>
<th>How many does it really take?</th>
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