Energy and the Physical Setting

Simple Machines, Part 7: Lever 2

Last week, we suggested that you draw a diagram of the hammer, scissors and a jack, to figure out the relationship between the size or magnitude of the force exerted by effort, the load and the distance of the load and the effort from the fulcrum. That relationship is one of the principles of the lever. How well do your diagrams match the following descriptions? What did you notice about how the magnitude of the force exerted by the effort and the load compare with the distance of the load and the effort from the fulcrum?

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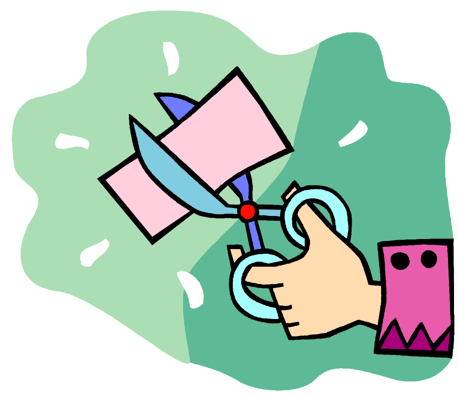
A hammer is one example of a lever where the **fulcrum** is between the effort and the load. Think about prying a nail out of a floor. The hammer is the actual **lever**, the amount of force you put into prying is the **effort**, the place where the hammer meets the floor is the supporting point or **fulcrum**, and the nail stuck into the floor is the **load**.

Another example is a pair of scissors cutting paper; this is actually two levers put together. The amount of force you put into cutting is the **effort**, the place where the two sections of scissors meet is the **fulcrum**, and the object that you are cutting is the **load**.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A third example is a car jack. The amount of force you put into pushing down is the **effort**, the place where the jack meets the car is the **fulcrum**, and the car that you are lifting is the **load**.


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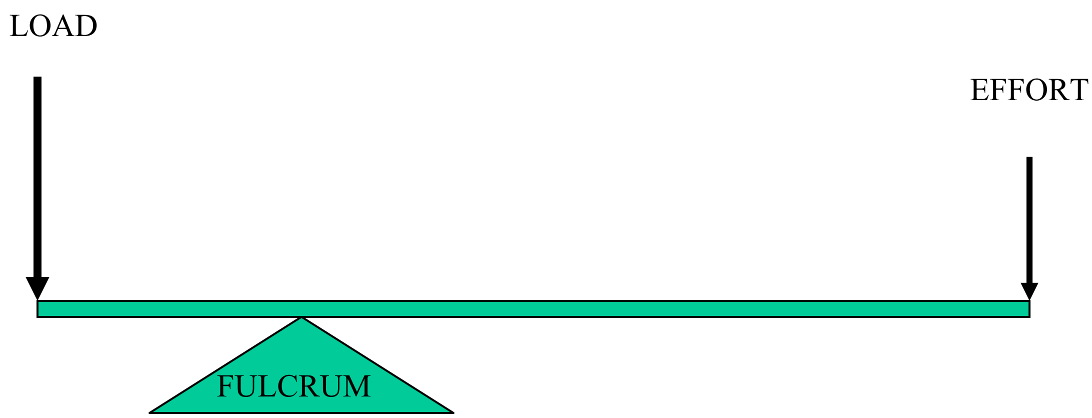
Principles of the lever

Principle 1:

The closer the load is to the fulcrum, the less effort (force) required to lift the load.

In each of the examples above, the distance from the load to the fulcrum is less than the distance of the effort from the fulcrum. To say it another way, the larger force has the shorter lever arm.



The lever balances if the force exerted by the effort (f) times the distance the effort force is from the fulcrum (L) equals the force exerted by the load (F) times the distance the load is from the fulcrum (l).

- f is the force exerted by the effort
- L is the distance the effort force is from the fulcrum
- F is the force exerted by the load
- l is the distance of the load force from the fulcrum

The lever balances when **f x L = F x l**

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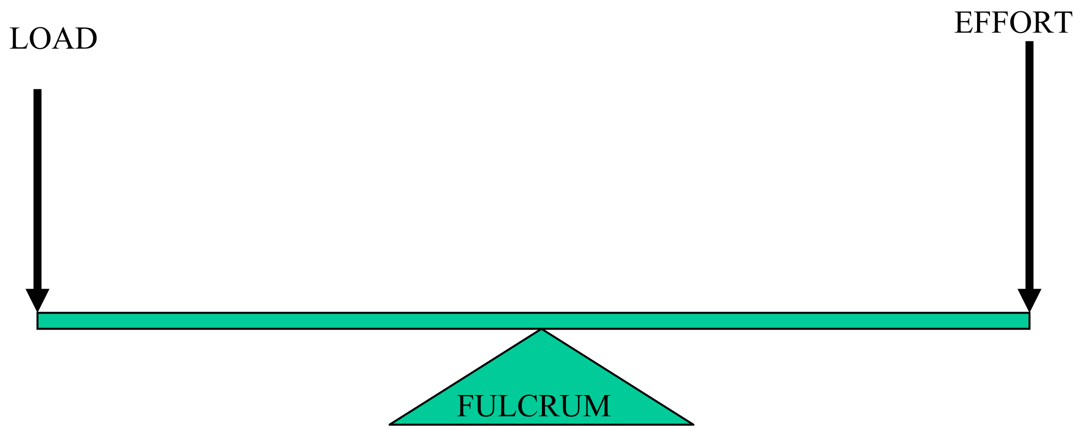
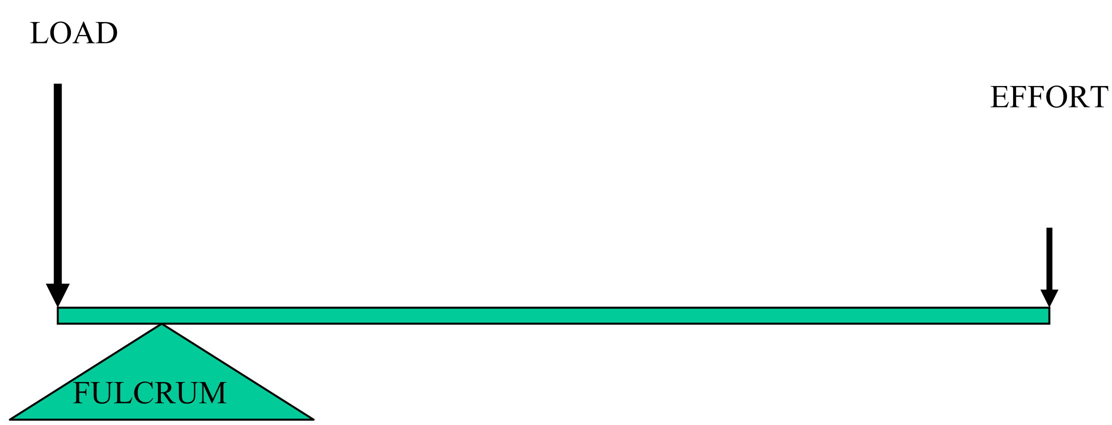
Imagine that you are using a lever to lift something that is very heavy. Where do you want to place the fulcrum? Suppose you put the fulcrum midway between you and the load? If both you and the **load** are equidistant from the **fulcrum**, you'd have to push incredibly hard to lift it; you may not even be able to budge it! The effort force would have to be greater than the load force. So what good is a simple machine then?



Plenty good. You just need to move the fulcrum closer to the load. The closer the load is to the fulcrum, the less force you need to exert to move the load.



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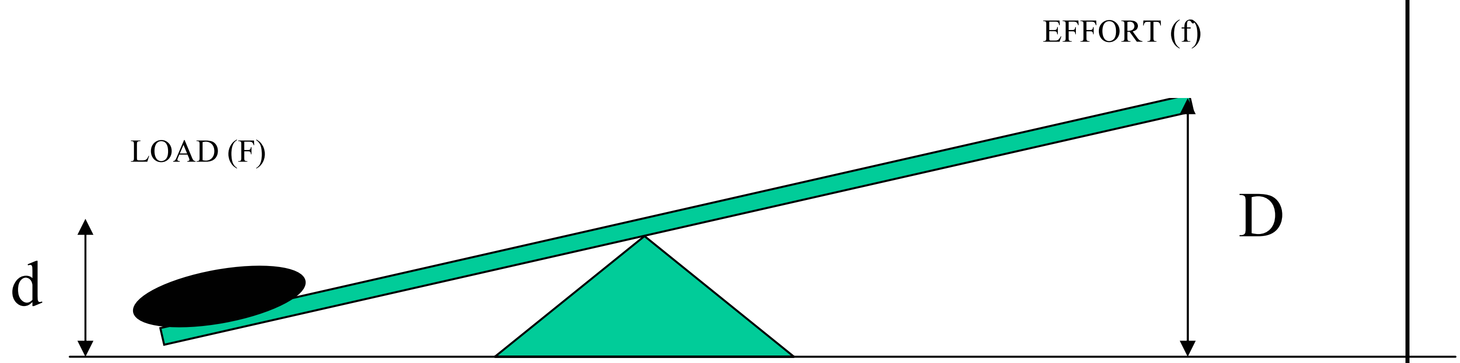
Principle 2:

The smaller force is exerted through a larger distance.



To lift the load (F) a distance (d), the effort (f) moves a distance D.

Principle 3:

The input work is greater than the output work.

For the effort to lift the load, the work input must be greater than the work output. Or to say it another way, when you use a lever, you put more energy into the lever than you get out. This is because some of the energy you put into the lever is used to lift the lever along with the load, and some energy is converted to heat because of friction.

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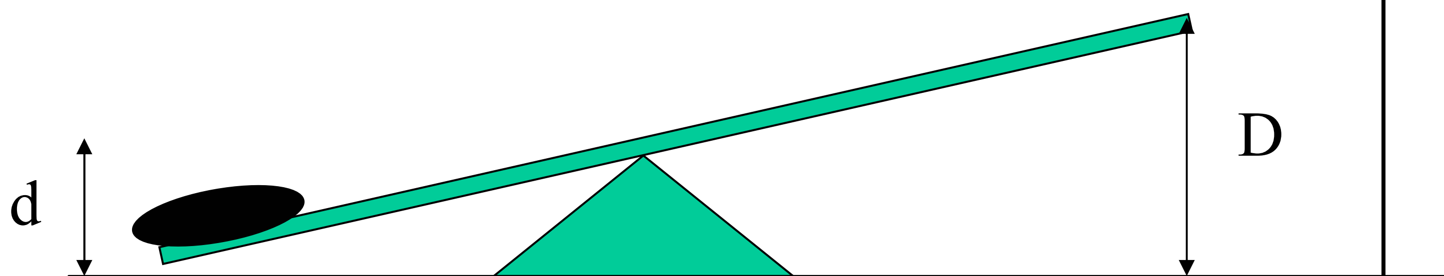
The work output from the shovel lifting the stone is equal to the weight of the stone times the distance the stone is moved upward. The work put into the shovel to lift the stone is equal to the push on the handle of the shovel times the distance the shovel is pushed downward.

Work output = F x d

Work put in = f x D

Work put in > Work output



To lift the load (F) a distance (d), the effort (f) moves a distance D.

Now here's a question for you: Is the amount of work you do when you use a lever such as a shovel to lift a rock (Example A) the same as, more than, or less than when you lift the rock without the lever (Example B)?

This is a tricky (but not trick) question because of the difference between scientific language and common language (again).

When we think of the ordinary usage of "work" (how much sweat and muscle are you going to have to use?), example A seems like less "work" because you exert less force. However in both examples above, the amount of scientific *work* done on the load is the same. The stone is lifted the same distance.

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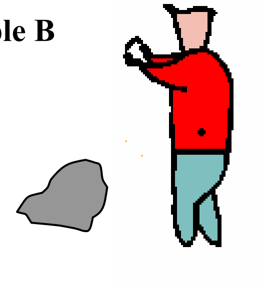
Example A

Example B



However, <u>you</u> actually do more work in the scientific sense when you use the shovel. That's because you are lifting the end of the shovel as well as the load. The language is subtle: There is the work done **on** the load and the work done **by** the person lifting the load. And the lever is in the middle, work is being done on it and by it.

Coming Up

Next week we're going to talk about the **wheel and axle** and the **pulley**.

- Which family do they fit into, **lever** or **inclined plane?** Why?
- Why do we use each simple machine? (multiply force or change direction of force?)
- What are some common examples of the **wheel and axle** and the **pulley**?

What do the NYS standards say?

In the <u>Elementary Core Curriculum, Standard 4, The Physical Setting</u>, one Major Understanding states:

- 5.1f Mechanical energy may cause change in motion through the application of force and through the use of simple machines such as pulleys, levers and inclined planes.

In the <u>Intermediate Core Curriculum, Standard 4, The Physical Setting</u>, Major Understandings state:

- 5.2f Machines can change the direction or amount of force, or the distance or speed of force required to do work.

- 5.2g Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. A complex machine uses a combination of interacting simple machines, e.g., a bicycle.

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