WOW sheet

Levers

A lever is one of the six types of **simple machines**.

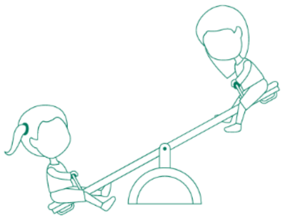
A machine is a device that does a physical task. **Simple machines** are the most basic devices that allow work to be done with less effort. A simple machine can change the direction or the magnitude of a force, or the point where the force is applied.

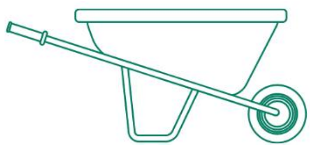
What is a lever?

> A lever is a bar that can pivot on a fixed point.
> It is a simple machine that can change the direction of force, multiply the force, or increase the distance travelled.

Common examples of levers include:

- seesaws
- wheelbarrows
- shovels





All levers are made up of some type of bar or beam and a fixed point called a **fulcrum**. The fulcrum is the pivot point for the lever. In other words, the lever will move at the fulcrum.

Force is applied to one part of the lever by pushing or pulling. This is the input force, often called the **effort**. The effort causes the lever to pivot at the fulcrum. This pivoting action is what allows the lever to output force, usually to move some object. The object moved by the output force is called the **load**.

Why use a lever?

Like all machines, levers allow you to get more work done with less effort. Levers change the input force in some way to make a task easier.

Different levers help in different ways. Some levers change the direction of the input force. Other levers multiply the input force. Still others increase the distance over which the force is applied.

There are three basic types of levers:

- first-class levers,
- second-class levers, and
- third-class levers.

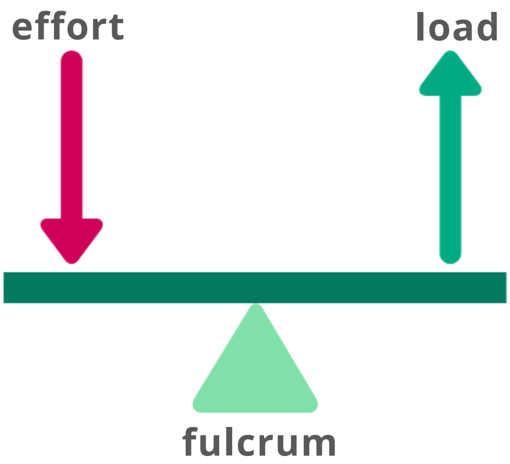
The location of the fulcrum, the effort, and the load differ for each type of lever. The type of work a lever does also depends on the position of the fulcrum, effort, and load.

First-class levers

The class of lever is always determined by which part (fulcrum, load, or effort) is in between the other two parts.

In a first-class lever, the fulcrum is between the effort and the load. When force (effort) is applied to one side of the lever, the load moves in the opposite direction.

In other words, first-class levers change the direction of the input force.

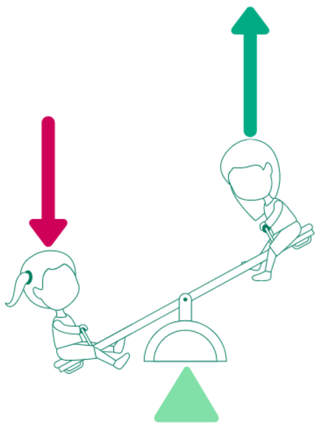


It doesn't matter which side of the fulcrum the effort is on compared to the load. It only matters that the fulcrum is in between the effort and the load. In fact, the position of the effort and the load might change as the lever is used!

Here's an example

A seesaw is a first-class lever. The fulcrum is always between the effort and the load.

But the effort and load change positions as the seesaw moves!



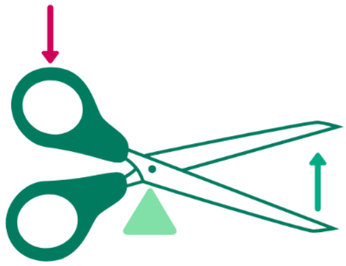
If you and a friend played on a seesaw, you would take turns being the effort, then the load, then the effort again. Each time you are lifted up, you are the load. And each time you do the lifting, you are the effort.

The fulcrum doesn't have to be in the exact middle of the load and effort either. It can be closer to one end of the lever than the other end. So long as the fulcrum is still in between the effort and the load, it is still a first-class lever.

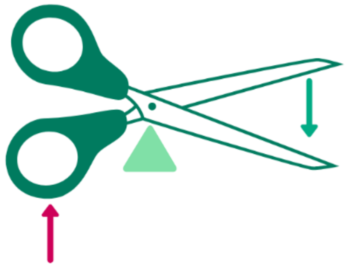
No matter where the fulcrum is located, it doesn't move with the lever. It stays in one place and the rest of the lever pivots around the fulcrum. This is true of all classes of levers, but it's very easy to see in first-class levers.

Here's an example

A pair of scissors is actually two first-class levers working together. This is sometimes called a double lever.



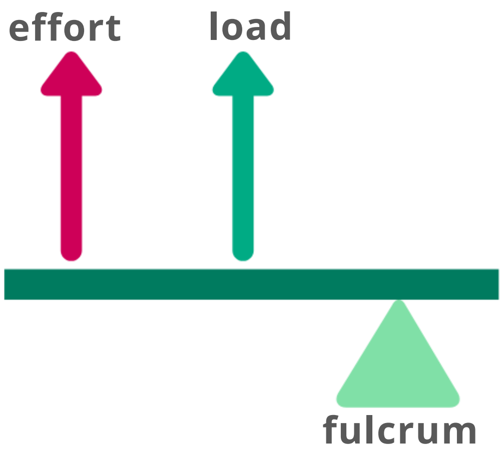
The two levers share a single fulcrum. This is the point where the levers are connected together. Usually, this fulcrum is closer to the handles than it is to the far end of the blades.



Each time you open and close the handles, you apply effort. The blades move in the opposite direction of the handles. The two levers work together, which is what allows the scissors to cut!

Next time you use a pair of scissors, watch the fulcrum as you open and close the scissors. The handles and blades pivot up and down from this point. But the fulcrum itself stays in one place the whole time.

Second-class levers



In a second-class lever, the load is between the effort and the fulcrum.

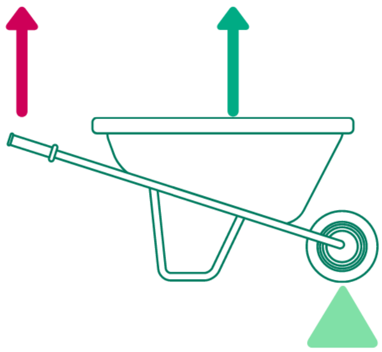
Second-class levers don't change the direction of the force. Both the effort and the load move in the same direction.

This class of lever multiplies the input force. In other words, second-class levers output more force compared to the input. This allows them to do more work to the load with less effort.

Here's an example

A wheelbarrow is a second-class lever. The load is always between the effort and the fulcrum.

When you lift up on the handles of the wheelbarrow, the middle, where the load is, also lifts. Using this lever, you are able to lift up a lot more weight than you could without it.



But there is a trade-off.

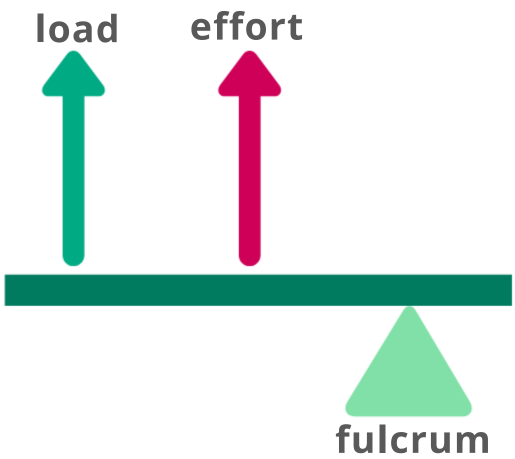
You have to lift the long handles up a fair way in order to raise the wheelbarrow's bucket. The bucket doesn't move as far a distance, but instead, it moves up with more force.

Third-class levers

In a third-class lever, the effort is between the load and the fulcrum.

Third-class levers don't change the direction of the force. Both the effort and the load move in the same direction.

They also don't multiply the input force.

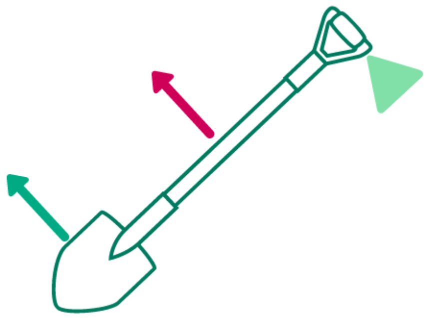


Third-class levers make work easier by increasing the distance over which the force is applied.

Here's an example

A shovel is a third-class lever. The effort is always between the load and the fulcrum.

When you scoop up dirt with a shovel, you put one hand on the top of the shovel's handle and the other on the middle of the shovel. The dirt, which is the load, sits on the shovel's scoop.



The hand on the middle of the shovel is the one that does the work. This hand lifts the shovel and the load up from the ground.

The advantage of a third-class lever is that the load moves farther than the effort. You only need to lift the middle of the shovel a bit to raise the scoop with its load of dirt up quite a lot.

Mechanical advantage of a lever

Like all simple machines, you can calculate the mechanical advantage of a lever by dividing the force of the load (also called the force of resistance) by the force of effort.

$$Mechanical\ Advange = \frac{Force\ of\ resistance}{Force\ of\ effort}$$

The ideal **mechanical advantage** (MA) for a lever is equal to the distance from the fulcrum to effort (d_e) divided by the distance from the fulcrum to the load (d_l).

$$\boxed{MA = \frac{d_e}{d_l}}$$

Here's an example

Think back to a wheelbarrow. Remember, a wheelbarrow is a second-class lever. The wheel is the fulcrum, the handles are where the effort is applied, and the load is in the bucket in the middle.

Let's say the distance between the fulcrum to the effort (d_e) is 130cm. The distance from the fulcrum to the load (d_l) is 65cm. That means the mechanical advantage of using the wheelbarrow is:

$$\frac{130cm}{65cm} = 2$$

What does that '2' mean? It means that the wheelbarrow multiplies your input force by 2 times.

You can think of it the opposite way too: however hard you work to lift the load, you would have to work 2 times harder without the wheelbarrow!