

WOW sheet

Pulley

A pulley 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 pulley?

A pulley is a grooved wheel with a rope, belt or chain wrapped around it.

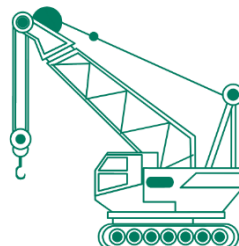
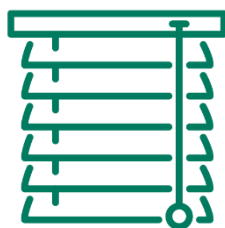
It is a simple machine that can change the direction of the force, multiply the force, or both change the direction and multiply the force applied to the pulley.

All pulleys consist of a rope or rope-like thing (such as a chain or a belt) and at least one grooved wheel. The rope fits into the groove in the wheel. Pulling on the rope turns the wheel.

Pulleys are often used as components in **compound machines**. A compound machine is a machine made up of two or more simple machines which work together to perform one task.

Common examples of pulleys include:

- window blinds
- cranes
- flag poles



Why use a pulley?

A pulley is actually a kind of **lever** that can change the direction of force or multiply the force. There are three types of pulleys:

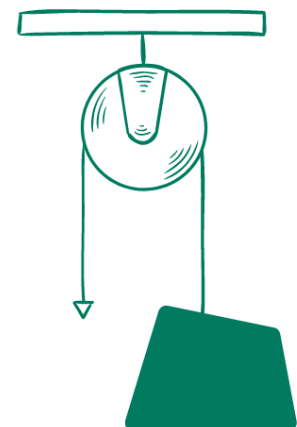
- single fixed pulley,
- single moveable pulley, and
- compound pulley.

The different types of pulleys behave in different ways and are used for different reasons. However, the most common reason to use any type of pulley is to help raise an object vertically.

Single fixed pulley

A single fixed pulley uses one grooved wheel which is 'fixed' in place. The load is connected to one end of the rope. The force is applied to the other end of the rope.

As you pull on the rope, the load moves in the opposite direction. Usually, this type of pulley is used to lift a load up by pulling down.



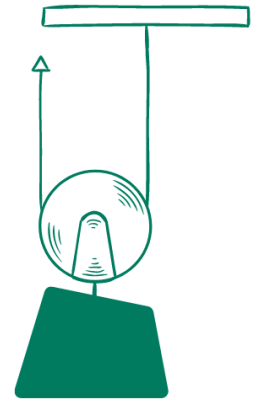
Here's an example

Many flagpoles use a single fixed pulley at the top of the pole. You attach the flag to one end of the rope, then pull down on the other end of the rope to raise the flag.

The load only moves up as much as the rope is pulled down. In other words, this type of pulley doesn't increase the force that is applied to it. However, it does change the direction of the force.

Single moveable pulley

A single moveable pulley uses one grooved wheel which is able to move on the rope. The load is connected to the pulley. One end of the rope is attached to a support. The force is applied to the other end of the rope. As you pull on the rope, the load moves in the same direction as you pull.



Because the load is attached to the pulley, the pulley moves with the load. This means that the pulley and the load are supported by two sections of the same rope. This multiplies the force, reducing the effort required to move an object vertically.

While a single movable pulley reduces the total force required to lift an object, it doesn't change the direction of the force. In other words, you need to be above the object you want to lift vertically to use a single moveable pulley.

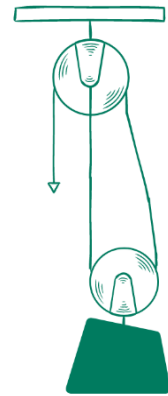
Here's an example

Some water wells use a single moveable pulley. The water bucket is attached to the pulley, which is lowered down into the well. Because the weight of the full bucket is supported by two segments of the same rope, it only takes half as much effort to pull the bucket back up out of the well.



Compound pulley

A compound pulley uses two or more grooved wheels with a single rope. This type of pulley is also called a block and tackle system. There is usually at least one fixed and one moveable pulley. The load is connected to the moveable pulley. The rope connects the pulleys together and the force is applied to the free end of the rope.



Because a compound pulley uses both a fixed pulley and a moveable pulley, it both changes the direction of the force and it multiplies the force. As you pull on the rope, the load moves in the opposite direction, just like in a fixed pulley. And just like in a moveable pulley, the load is supported by multiple sections of the same rope. This multiplies the force, reducing the effort required to move an object vertically.

Here's an example

Construction cranes use compound pulleys to lift heavy loads up high. The moveable pulley reduces the total force that is needed. The fixed pulley changes the direction of the applied force.

Changing the direction of the force is just as important as reducing the effort required. Why? By changing the direction of the force, a downwards pull lifts an object up. This is very helpful, because it allows you to use weights to counterbalance the load, letting gravity do some of the work!

Mechanical advantage of a pulley

Mechanical advantage compares the force produced *by* a machine with the force applied *to* the machine. When the machine increases the force applied, there is a mechanical advantage.

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

$$\text{Mechanical Advantage} = \frac{\text{Force of resistance}}{\text{Force of effort}}$$

However, there is an even easier way to calculate the mechanical advantage of a pulley.

To calculate the mechanical advantage of a pulley, you can simply count the number of rope sections that support the object being lifted. In other words, you count the number of rope sections pulling *up* on a load.

The ideal **mechanical advantage** (MA) for a pulley is equal to the number of rope sections supporting the object.

$$MA = \text{rope sections pulling up}$$

Be careful, however. You only count the rope sections that are supporting the object. You don't count rope that is just attached to the load, but not actually supporting it, or sections pulling down.

Remember, a machine makes work easier by changing the direction or the magnitude of a force. All pulleys are machines, but not all pulleys output more force compared to the input.

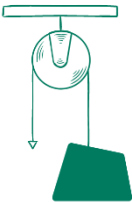

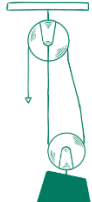


In the single fixed pulley, only one rope segment pulls up on the load. This means that the mechanical advantage is 1. In other words, the output is the same as the input.

In the single moveable pulley, two rope segments pull up on the load. This means that the mechanical advantage is 2. The output from the pulley is increased by a factor of 2.

In a compound pulley, at least two rope segments pull up on the load. This means that the mechanical advantage is 2 or greater than 2. The mechanical advantage will depend on the number and the arrangement of the pulleys, but it will always be at least 2. You can make very complex systems of compound pulleys. The more sections of rope supporting the load, the greater the mechanical advantage.

👁 Here's an example

	Single fixed pulley	Single moveable pulley	Compound pulley
			
Number of rope sections pulling up on the load	1	2	2
Mechanical advantage	1	2	2
Changes direction of the force?	Yes	No	Yes

