WOW sheet

Gears

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.

A **compound machine** is a machine made up of two or more simple machines which work together to perform one task. Gears are a type of compound machine. A gear is a toothed **wheel and axle** where the teeth act like **levers**.

What are gears?

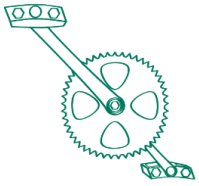
Gears are toothed wheels and axles. Two or more gears work together in mated pairs. The teeth on each gear mesh in with the teeth on the other gear. The teeth work like levers, transferring motion or power between the gears.

Gears are compound machines that can change the speed, the size, or the direction of a force.

Gears are used as a component in many different mechanical devices. There are many different shapes and sizes of gears and they can be connected together in different ways. Sometimes you can see the gears, but they are often out of sight.

Common examples of devices that use gears include:

- watches
- can openers
- bicycles



Why use gears?

Gears are sometimes added to lists of simple machines, but this isn't quite right. Because you need at least two gears to perform a task, gears are compound machines. Even then, it's unusual to have a machine that just uses gears. Usually, gears are one part of a bigger compound machine.

The most common role that gears have inside machines is transferring motion or power between the gears, moving it from one part of a machine to another.

Here's an example

Think about a bicycle.

The rider is the power source for this machine. They power the bicycle by pedalling. The gears of the bicycle (with the help of a chain) take that power from the pedals and transfer it to the back wheel.

This turns the wheel, which is what moves the bicycle forward.

All machines have some form of power source. This is what gives the machine its energy. Gears can be used to change the speed or force of the power source, either increasing it or decreasing it. They can also be used to send the force from one part of the machine off in another direction.

The size, shape, and position of the gear determine the gear's function in a machine.

The three main reasons to use gears are:

1. Change the speed of a force.
2. Change the size of a force.
3. Change the direction of a force.

Change the speed of a force

One thing that gears are commonly used for is to change the speed of a force inside a machine.

When gears are being used in this way, one gear is usually connected directly to the power source. The power source makes this gear, called the **drive gear**, move. The first gear is then connected to another gear, called the **driven gear** or the following gear, and transfers the motion to that next gear.

Different gears are different sizes. In general, gears with more teeth are bigger than gears with less teeth. Using gears with different numbers of teeth mated together will change the speed of the force as it is passed from gear to gear.

If the first gear (the drive gear) has more teeth than the second gear (the driven gear), the second gear has to turn much faster to keep up. Because the gears are connected, both gears rotate one tooth at a time. The gear with fewer teeth ends up doing more rotations to keep up with the gear that has more teeth. This means that the second gear turns faster than the first gear, speeding up the force.

The opposite is also true. If the second gear has more teeth than the first gear, then it will turn slower, slowing down the force.

There is a trade-off to changing the speed of a force using gears: the size of the force. Simply put, to get more speed out of a gear, you get less force.

Change the size of a force

Another thing that gears are commonly used for is to change the size of a force inside a machine.

There is always a trade-off between the speed of a force and the size of the force as it is passed from gear to gear. Using gears with different numbers of teeth mated together will change both the speed and the size of the force as it is passed from gear to gear.

If the drive gear (the first gear) has more teeth than the driven gear (the second gear), the driven gear has to turn much faster to keep up. While the driven gear turns faster than the drive gear, it also turns with less force. In other words, you can reduce the force by having the second gear in the chain have fewer teeth.

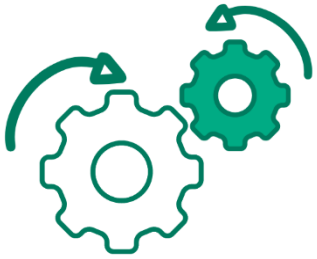
The opposite is also true. If the second gear has more teeth than the first gear, then it will turn with more force, but much slower.

Anytime a gear increases a force, it must also reduce the speed. If the gear increases the speed, it must also reduce the force.

Change the direction of a force

Changing the direction of a force inside a machine is another reason to use gears.

When two gears mesh together, the second one always turns in the opposite direction from the first. If the first gear turns clockwise, the second one must turn counter-clockwise.



Gears can also be connected in different ways (such as perpendicularly to each other) to change the direction of a force, sending it off in a different direction. There are also special gears that are used to send the force from a power source off at an angle.

Mechanical advantage of gears

The mechanical advantage of gears compares the force input by the power source to the force output by the gear system. You can calculate the mechanical advantage (MA) by dividing the force of resistance (which is the load) by the force of effort.

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

Because gears are a type of wheel and axle, the mechanical advantage gears provide is similar. However, gears work together, so the advantage really comes from the difference between the two gears. This is known as a **gear ratio**. The mechanical advantage of a gear system is equal to its gear ratio.

Gear ratio

A **gear ratio** is a measure of the ratio of the rotational speeds of two or more interlocking gears. You can think of this as the ratio of complete turns two gears make when they are connected together.

If you just have two gears, a drive gear connected to the power source and a driven gear, then the gear ratio is a comparison of the number of teeth on each gear. The number of teeth in the driven (second) gear is divided by the number of teeth in the drive (first) gear to give the gear ratio.

Formulaically, it can be written as:

$$Gear\ ratio = \frac{Number\ of\ teeth\ on\ driven\ gear}{Number\ of\ teeth\ on\ drive\ gear}$$

Remember that there is always a trade off between the speed and the size of a force as it is passed between gears. The gear ratio tells us the value of this trade-off.

Here's an example

Imagine a set of two gears, where the drive gear has 20 teeth and the driven gear has 10 teeth. That means the gear ratio is:

$$\frac{10}{20} = \frac{1}{2}$$

The gear ratio is ½ but this is often written as a ratio, 1:2.

What does that '1:2' mean? It means that driven gear will rotate 2 times for every 1 time the drive gear rotates. That means that the output of the system is 2 times as fast but with ½ as much force as the input.