

## WOW! on Wheels – Educational Activities

### SIMPLE MACHINES (grades 3-5)

Learning Objectives:

- Understand a machine, a Simple Machine, and a Complex Machine.
- Identify the 6 types of Simple Machines.
- Recognize examples of simple machines that we see or use every day.
- Understand how simple machines make work easier.
- Understand the connection between simple machines and force.

#### **What is a machine?**

Early man invented the first machines over 2 million years ago. These were rock axes. People made windmills and water movers thousands of years ago. Even monkeys and some other animals use simple machines like sticks and rocks to get food.

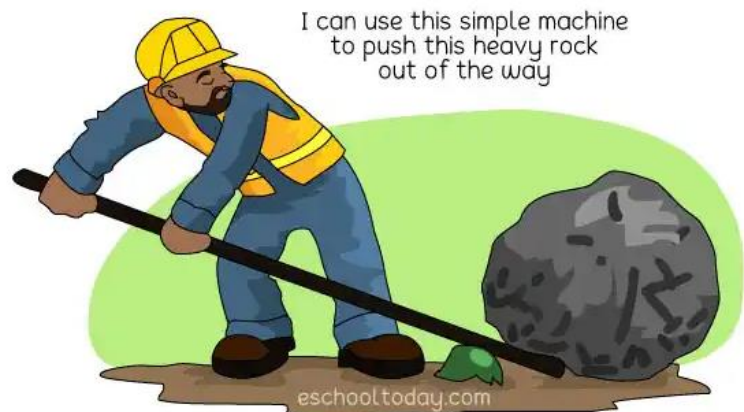
A machine is any device that does work. Machines make our lives easier because they reduce the amount of energy, power, and time we need to get something done.

Machines come in many sizes, shapes, and forms. Some machines are simple, while others are very complex. For example, a spade is a machine (a simple machine), and a space shuttle is a machine (a complex machine).

A simple machine is a tool, device, or object with few moving parts that help us do work. Simple machines have been in use for a very long time. Early humans used simple machines to push, pull, lift, divide, and crush things. They used simple machines to row rafts over water, build houses, split firewood, and carry heavy items from place to place. Today, there are simple machines everywhere and all around us.

The main purpose of simple machines is to make work easier. If they were not available, some tasks would be impossible.

There are six types of simple machines — the inclined plane, the wedge, the screw, the lever, the wheel and axle, and the pulley. These six machines have specific features and do unique jobs, even though some may work in similar ways.





It is important to understand that simple machines, unlike complex ones, do not work on their own. They only increase the pull or push (force or effort) that a person uses, increase or decrease the distance needed, or change the direction of a movement so that more work is done.

### Features of a Simple Machine

- They do not use electricity.
- They have one or fewer moving parts.
- They give us a mechanical advantage.
- Even though they make work easier for us, they still need input (force or effort) from a person.
- They make tough jobs easier by changing the force, direction, or speed of a movement.

### What is a Complex Machine?

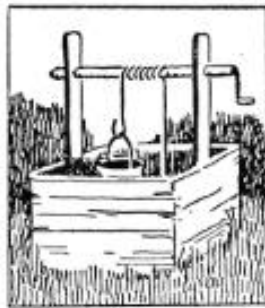
Simple machines are different from complex (or compound machines). Complex machines, like trucks or wagons, or bicycles, use many moving parts. They combine many simple machines such as levers, pulleys, and gears to get work done.

Let's take a look at each kind of Simple Machine, and what they do.

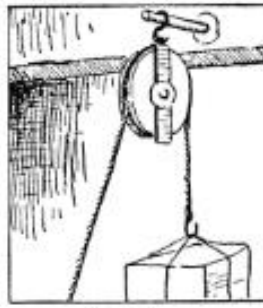
Remember, there are six simple machines: Inclined Plane, Lever, Pulley, Screw, Wedge, and the Wheel and Axle.



Lever



Wheel and axle



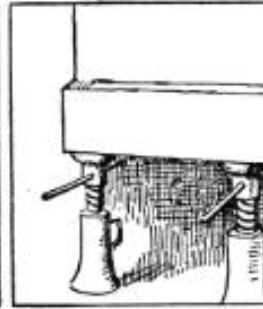
Pulley



Inclined plane



Wedge



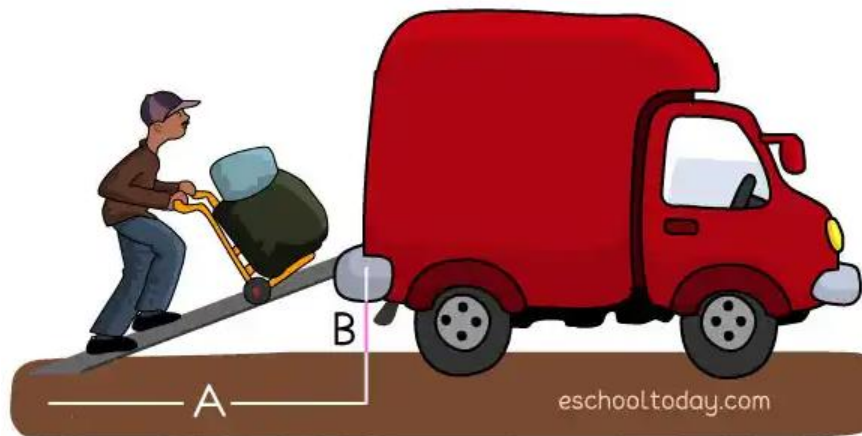
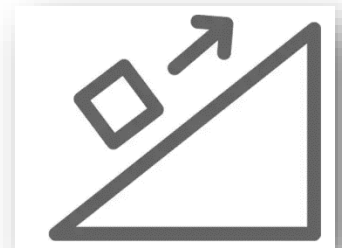
Screw

## Inclined Planes

An inclined plane is exactly what its name says. It's a plane (a flat surface) that is inclined, or in other words, slanted or sloped. This simple machine makes it easier for us to move heavy objects to higher or lower surfaces than if we lifted the objects directly upwards.

It is easier to move heavy things up a ramp than it is to lift them straight up. The slanting surface supports some weight of an object as it moving upwards, making us use less force. However, the object must move at a longer distance than it would on a straight surface. An object will use less force to move upward in an inclined plane with a more gradual slope.

'Inclined' means a raised end or raised at one end. An inclined plane may be a constructed frame or just a piece of log leaning against a higher point. An inclined plane is also called a ramp. It may take longer to go up the ramp, but it is easier. One of the most common applications of inclined planes is getting heavy objects into a truck using a ramp. Less force is required to get the object inside the vehicle, the tradeoff being covering a longer distance.



What is an Inclined Plane?

## **Trade-off**

There is a trade-off with this simple machine. If the slope is gentle, a person has to push or pull the object over a longer distance, but with little effort. If the slope is steep, a person has to push or pull the object over a very short distance, but with more effort.

The Trade-off helps us to understand the mechanical advantage of inclined planes. For example, there is a greater mechanical advantage if the slope is gentle because less force will be needed to move an object up or down the slope.

Types of inclined planes include a wheelchair ramp, a slide, and a slanted roof.

Gentle slope means less force needed but more distance will be covered.

Steep slope means more force needed but shorter distance covered.



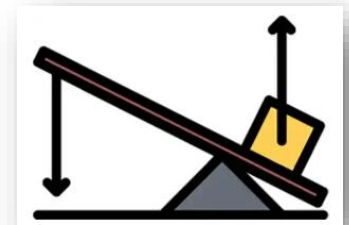
Greater Mechanical Advantage



Mechanical advantage

## Lever

A lever also helps move heavy objects. It is simply a plank or ridged beam that is free to rotate on a pivot. It is perfect for lifting or moving heavy things. A lever makes work easy by minimizing the amount of force required to lift or move the load by lengthening the distance in which the force acts.

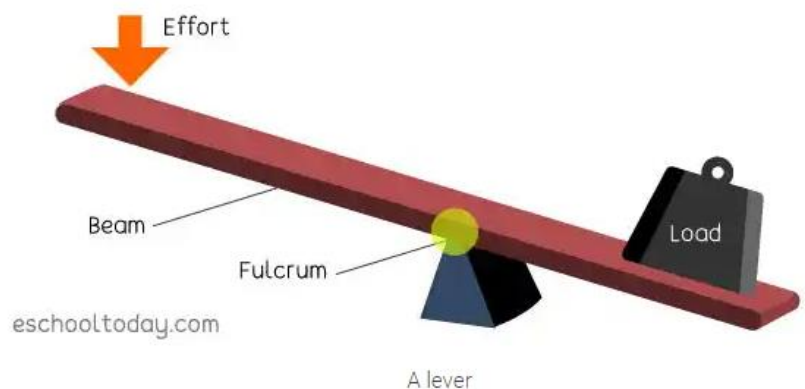


Lever will not increase or decrease the amount of energy needed to move or lift objects. Instead, they spread the effort applied to them over a longer distance. Simply put, when you push down on one side of a lever, the other side goes up. Levers can be used to lift heavy objects such as a rock or furniture.

Lever has four important parts — the bar or beam, the fulcrum (the pivot or the turning point), effort (or force), and the load.

The beam is simply a long plank. The beam rests on a fulcrum (a point on the bar creating a pivot).

When you push down one end of a lever, you apply a force to it. Does this sound like anything you've used on the playground? The lever pivots on the fulcrum and lifts a load by exerting a force on the load. A lever makes work easier by both increasing your input force and changing the direction of your input force.

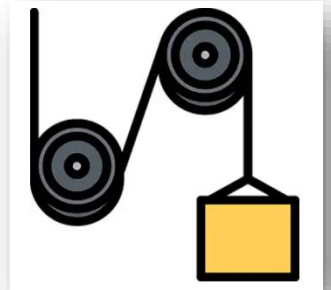


Common types of levers include wheelbarrows, seesaws, crowbars, fishing-line, oars, a garden shovel, and scissors.

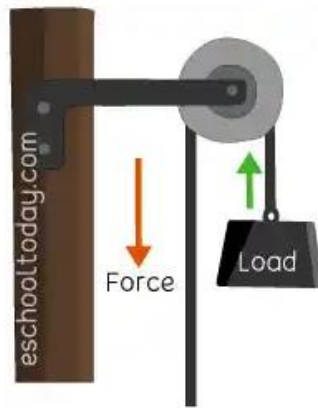


## Pulley

Have you seen your school flag raised? That happens because of a simple pulley. When you pull down on the rope, the pulley at the top of the pole turns, and the flag goes up. A pulley is a simple machine that makes it easy to lift objects (sometimes heavy) and allows you to change the direction of a force. It moves things from a low area to a higher one and usually has a wheel and a rope that goes through its rim. As you pull down on the rope, the wheel turns and whatever is attached to the other end goes up.



A pulley is simply a wheel with a groove and a rope in the groove. The groove is important because it helps to keep the rope in place. With a pulley, the item to be lifted is tied to one end of the rope. A person usually pulls down on one side of the rope, which makes the other side move upwards. The downward force turns the wheel with the rope and pulls the load upwards at the other end. It can have one or more wheels. A pulley with more than one wheel makes work even easier since the force pulling one side of the rope is increased.

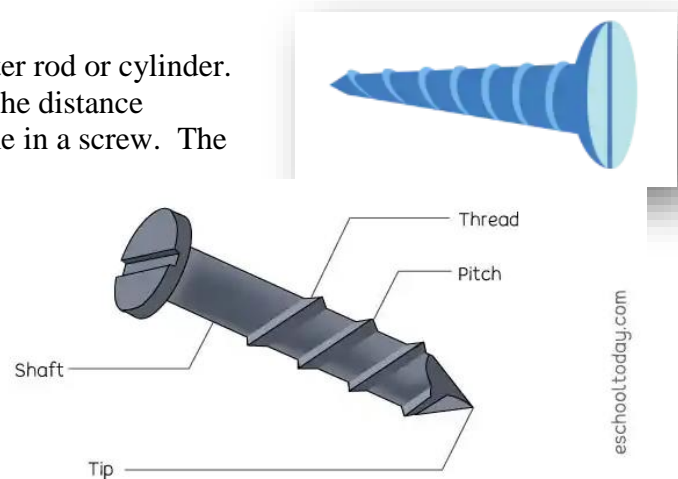


Common types of pulleys include a cargo system, a crane, an engine, a flag pole, a bulldozer, and an escalator.

## Screw

A screw is an inclined plane wrapped around a center rod or cylinder. It also has ridges around it, known as the threads. The distance between one thread and the other is usually the same in a screw. The distance between threads is called a Pitch.

Screws are useful for holding things together. They can pull or push an object together. They can be used to lift heavy items and tighten things too. Screws are not the same as nails, the difference is that nails don't have threads.



The screw as a simple machine

Common types of screws include bolts and drill bits.

A bolt is a kind of screw but does not have a pointed tip. A bolt is not drilled into place, but rather, a hole is made for the bolt to go through. Then a nut is placed at the end to screw the bolt through. Bolts are powerful in holding things together.

A drill bit is a type of screw that can make holes in wood, plastic, metal, and stones when attached to an electric drill.

Like the regular drill, it is pointed at one end, and it has threads too. The drill bit has deeper grooves that carry pieces of the wood from the hole to the surface as the drill bit turns.



Bolts, nuts, and drill bits

Some good examples of screws are bolts, screws, bottle tops, guitar tuners, light bulbs, faucet taps, and cork openers.



## Wedge

A wedge is simply a triangular tool, often made of metal, wood, stone, or plastic. It is thick on one end and tapers to a thin or sharp edge on the other end. Technically it is an inclined plane or ramp (or two inclined planes put together to form a triangle) that moves. Wedges make work easier by increasing the distance over which an object moves while decreasing force. Longer edges make work easier than shorter ones since they have an extra mechanical advantage.

A wedge may be attached to a handle to make it easier to use.

A wedge can be used in many ways:

- to cut (knife)
- to split (axe)
- to tighten and to hold back (doorstopper)
- to hold together (nail)
- to scrape (blades on the snowplow or farm grader)

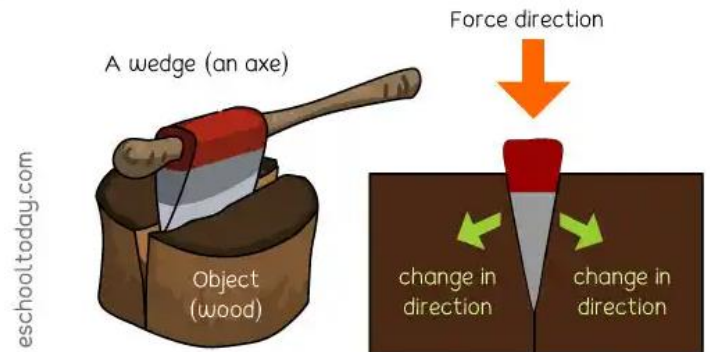


Wedges work by changing direction and force applied to it. For example. A wedge can be used to split material. By placing the thin end of the wedge onto a log, you can hit it with a hammer. The wedge changes the direction of the force and it pushes the log apart.

You will notice, in the picture, that the force applied to the thick end of the wedge overcomes the resistance of the wood. The force is directed downwards, but the wedge directs the force sideways as it drives into the wood.

### Trade-off

The longer and thinner a wedge is (sharper), the more work it does with little effort. If the wedge is shorter and has a wider angle at the tip, we need more force to do the work.



Human beings have been using wedges for millions of years ago. In ancient times, people would use wedges made of hard rocks and stones to hunt (like spears), cut and trim trees, and carve stones. The ax is also one of the ancient wedges made by man. One of the applications of wedges in real life is modern cars and jets. Trains, jets, fast cars, and speed boats have pointed front parts that help them cut through the air with less resistance. This feature of pointed noses cutting through air is known as aerodynamics.

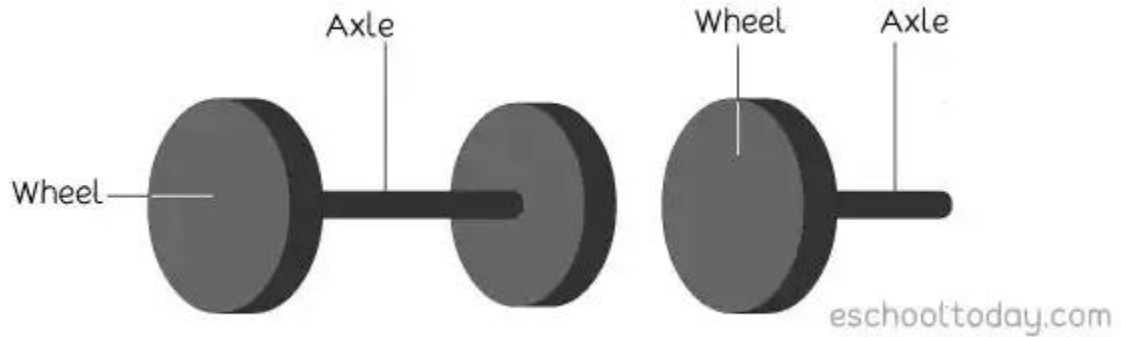
Good examples of wedges are nails, knives, chainsaws, axes, scissors and your teeth!

### Wheel and Axle

The wheel and axle are some of the most commonly used simple machines. Before its invention, there were so many transport limitations, especially when heavy goods were to be taken to longer distances. A wheel and axle is a simple machine with a wheel with a groove, with a rod running through it (the axle).

A wheel and axle reduce friction by allowing things to roll, which makes them rub against each other less, making work easier. It involves two circular objects — a larger disc and a smaller cylindrical object or rod is referred to as the axle. Sometimes, there may be two wheels attached to both ends of the axle. A wheel alone or an axle alone is not a simple machine. They need to be joined to be called a simple machine.





### What is a Wheel and Axle Simple Machine?

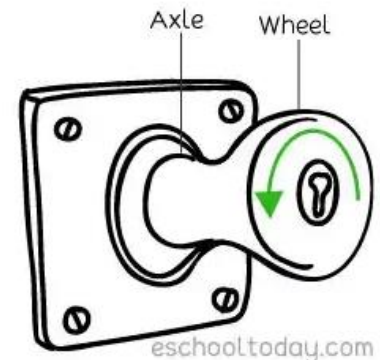
If you look closely at how a wheel and axle work, you will notice that it is similar to a lever. Here, an action on the axle (turning the axle) will cause output at the other end (the wheel turns too). The fulcrum is where the axle meets the wheel.

The Wheel and Axle work in two ways:

Force applied to wheel:

Let's take a screwdriver for instance. If you apply a force to the wheel (the handle), the wheel spins and multiplies the effort to make the output force of the axle (the shaft) greater.

A simple doorknob is another example of the wheel and axle. The locking mechanism of the doorknob is inside of the door and can only be controlled by the knob. Since it will be difficult turning the axle to open the door, we can turn the wheel instead and that does the job for us.



Force applied to axle:

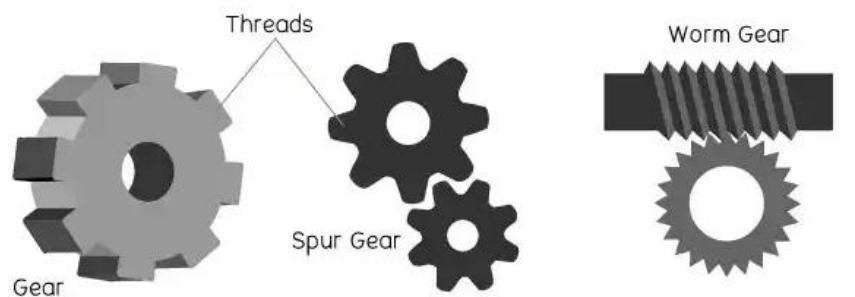
Think about a windmill. If you apply a force to the axle, it will multiply the force to the wheel (blades) and result in a greater distance covered. It is because the wheel is larger than the axle and covers more area. A ceiling fan works similarly. As the axle turns, it powers the larger wheel (fan blades) to cause the desired output.



The Wheel and axle are perfect for turning turbines and fans; they are also used in automobiles. For example, when you turn the steering wheel of a car, your effort is multiplied by the axle and results in more turns of the car wheels.

### Gears

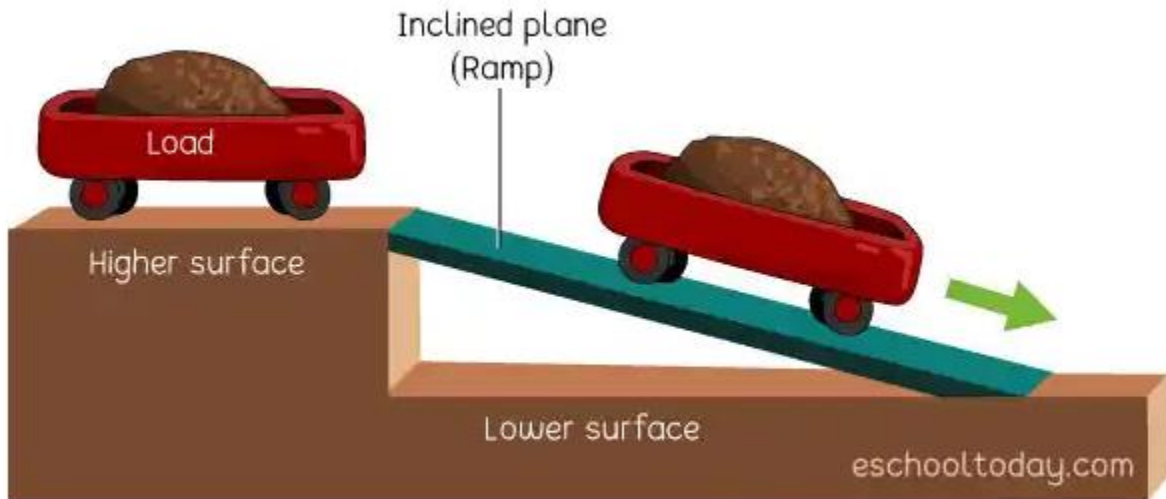
A gear is simply a special wheel with teeth called threads on the outside. Gears are usually arranged in more than one wheel. They are arranged with their teeth interlocking. The combination can include small and large wheels. When one wheel is in motion, it transfers its motion and force to the connected wheel by moving its teeth. Larger wheels turn slower than smaller wheels. Two wheels with meshed teeth always turn in the opposite direction.



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Types of gears

## Let's look at a few examples.



A simple machine

To bring the load (the wagon with a mound of dirt in it) to the lower surface, a person has to carry that carefully. That is a lot of muscle work. To make that a bit easy, we can just put a ramp there and give the wagon a little push — right? Yes, and then the load will slide down on its own.

In the example above, we have used a simple trick of a simple machine to bring down that load of dirt.

Here is another scenario:

A bulldozer at work – a combination of simple machines (levers, wheel and axle, wedge) that are combined to build a complex machine.

To push a mound of dirt on a piece of land, it can take a person with a shovel a lot of time and energy. However, one person with a complex machine can do that work in no time. Here, the complex machine, which is a combination of simple machines uses mechanical energy and electrical energy to do that job. It is not the same as a simple machine. This bulldozer is an example of a compound or complex machine.



A complex machine

Many of the machines we use today are a combination of various simple machines, like the bicycle. It usually has the following simple machines.

Wheel and axle: the pedals, cassette, wheels, and crankset  
Pulleys: braking mechanism, drive train, shifting mechanism, and chains on the gears  
Levers: handlebars, brakes, and gear shifters  
Inclined planes: tire repair kit, chain-link teeth, screws that hold it together



Since a bicycle is a compound of simple machines, it also makes work easier. How does it accomplish this? If you choose to walk, you're going to need a lot of time and energy. Using a bicycle can help you reach your destination faster and using less energy.

### **Fun Facts about Simple Machines**

- Simple machines were first discovered and described by Greek philosopher Archimedes.
- It is believed that ancient Egyptians used inclined planes to carry heavy stones to build pyramids. Using ramps would have made getting the large stones to the top much easier.
- Galileo was the first to work out a working mathematical theory on how simple machines worked.
- Your bicycle makes use of nearly every kind of simple machine in order to make a more complex machine.
- The wheel and axle was an important invention in the history of mankind. It was first used around 5,000 years ago by the Sumerians.

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