WOW! on Wheels – Educational Activities

SIMPLE MACHINES (grades 6-8)

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.

For thousands of years, humans have used machines to help them perform difficult tasks. Simple machines work by taking a force and making it bigger. A big force working for a short time can do the same amount of work as a small force working longer. Simple machines can help us to lift or move objects that would be too heavy to move by hand.

What is a machine?
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 one thing done by allowing a greater input.
A machine can increase the magnitude, or the distance of a force but not both at the same time.

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 sole 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 have specific features and do unique jobs, even though some may work in similar

ways. Some simple machines may be a combination of simple machines.

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, or change the direction of a movement so that more work is done.

What is a Simple Machine?
A simple machine refers to a device with few or no moving parts used to modify motion and a force's magnitude to do the work more easily. They accomplish this by:

- transferring force from one point to the other
- changing the direction of a force
- increasing the amount of force
- increasing the speed or distance of a force

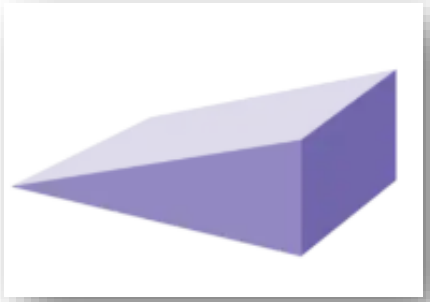
Features of a Simple Machine

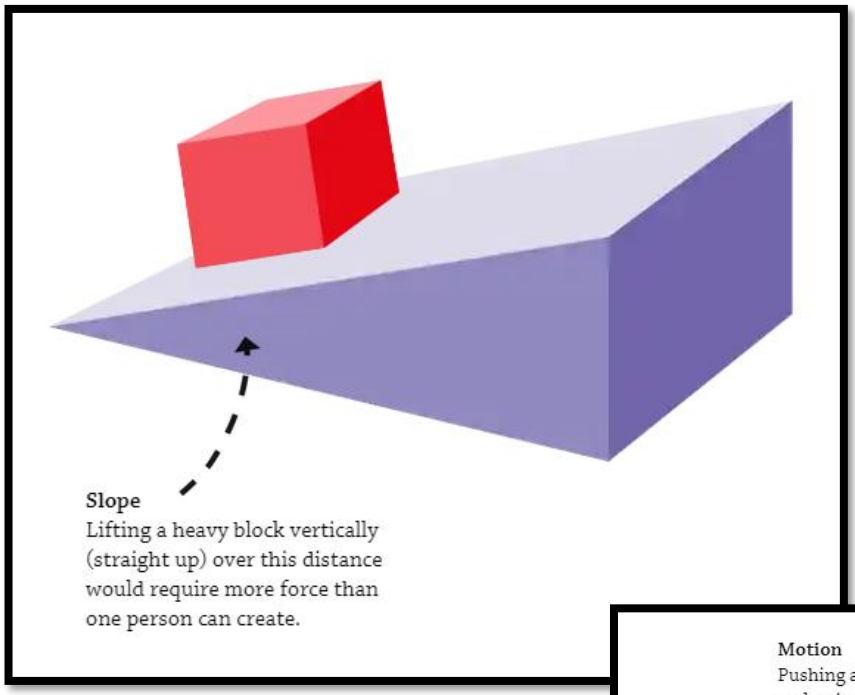
- They do not use electricity.
- They have one or fewer moving parts.
- They give us a mechanical advantage.
- Even though they make work easier for us, they still need input (force or effort) from a person.
- They make tough jobs easier by changing the force, direction, or speed of a movement.

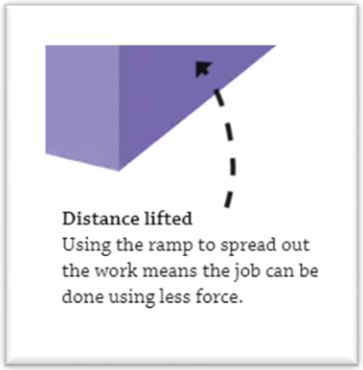
What is a Complex Machine?
Simple machines are different from complex (or compound machines). Complex machines, like trucks or wagons, or bicycles, use many moving parts. They combine many simple machines such as levers, pulleys, and gears to get work done.

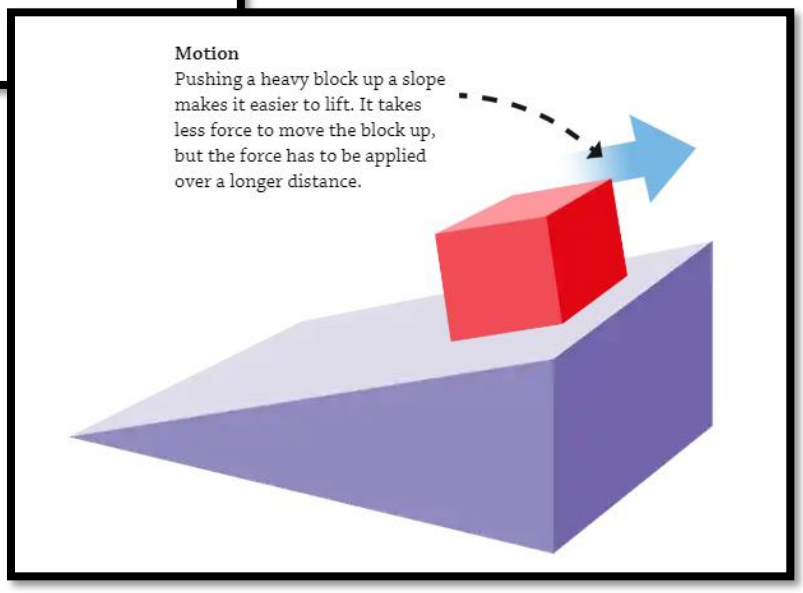
Remember, there are six simple machines: Inclined Plane, Lever, Pulley, Screw, Wedge, and the Wheel and Axle.

INCLINED PLANE – This simple machine makes it easier to move heavy objects. Inclined planes use slopes to make forces bigger or smaller. Ramps turn a difficult lifting job into an easy one by spreading out the lift over a distance, so it requires less force.



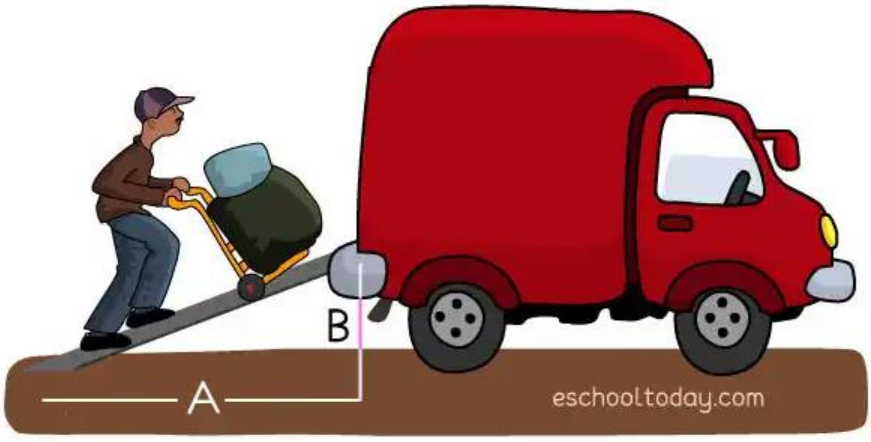






It is easier to move heavy things up a ramp than it is to lift them straight up. The slanting surface supports some weight of an object as it is moving upwards, making it use less force. However, the object must move at a longer distance than it would on a straight surface. An object will use less force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

A ramp is a common example of an inclined plane. It may take longer to go up one, 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 is that you are covering a longer distance.



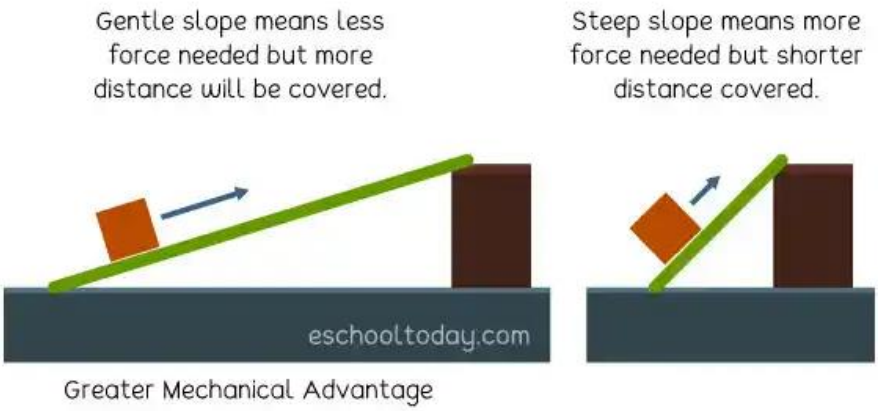
What is an Inclined Plane?

An inclined plane has a horizontal side (A), (the distance from the lower end of the slope to the base of the vertical). It also has a vertical side (B), (from the base up to the top of the sloped surface). The sloped surface is where the man is pushing the load.

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.

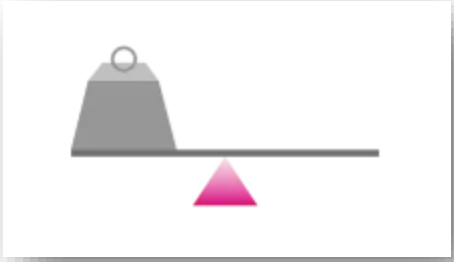


Greater Mechanical Advantage

Mechanical advantage

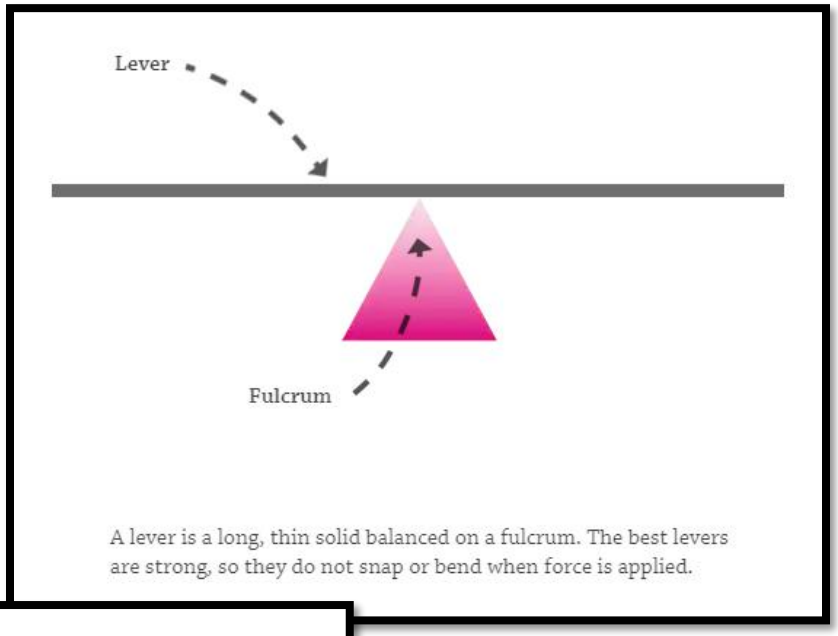
Other types of inclined planes include a wheelchair ramp, a slide, and a slanted roof.

LEVERS – A lever also helps move heavy objects. It is simply a plank or ridged beam that is free to rotate on a pivot. 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.

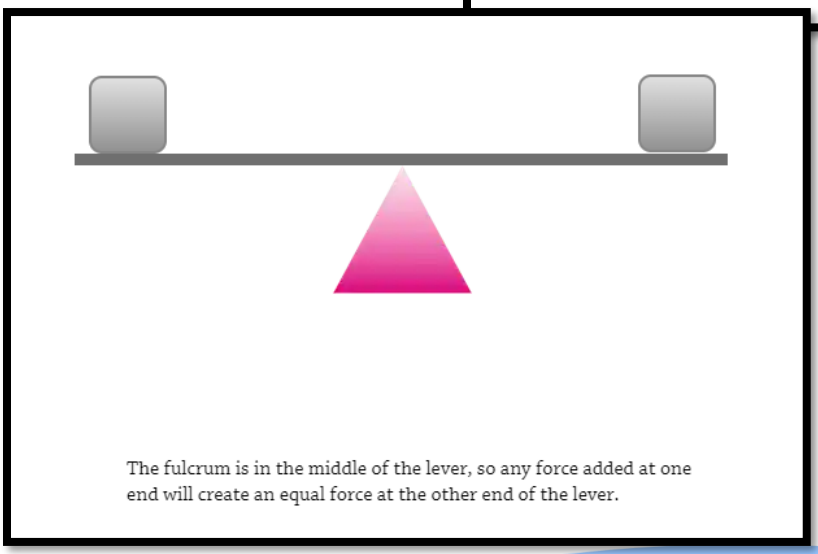


Levers will not increase or decrease the amount of energy needed to move or lift objects. Instead, they spread the effort applied to them over a longer distance. Simply put, when you push down on one side of a lever, the other side goes up. Levers can be used to lift heavy objects such as a rock or furniture.

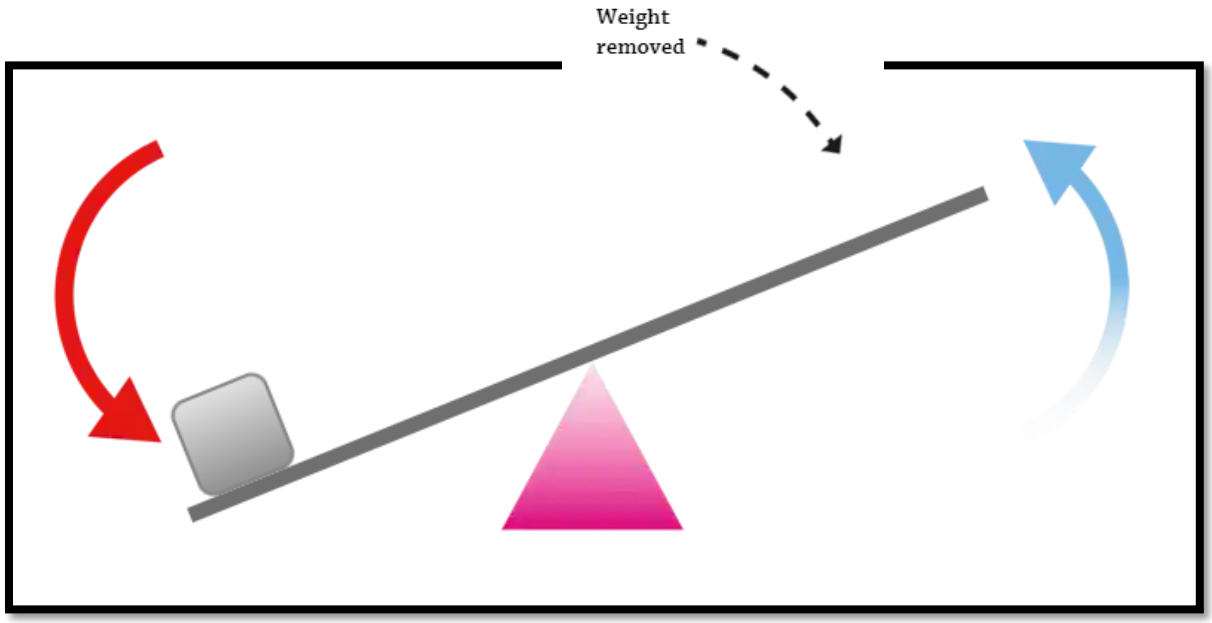
Levers are important parts in many tools, from hammers and crowbars to see-saws, bicycle pedals, nutcrackers, and tweezers.

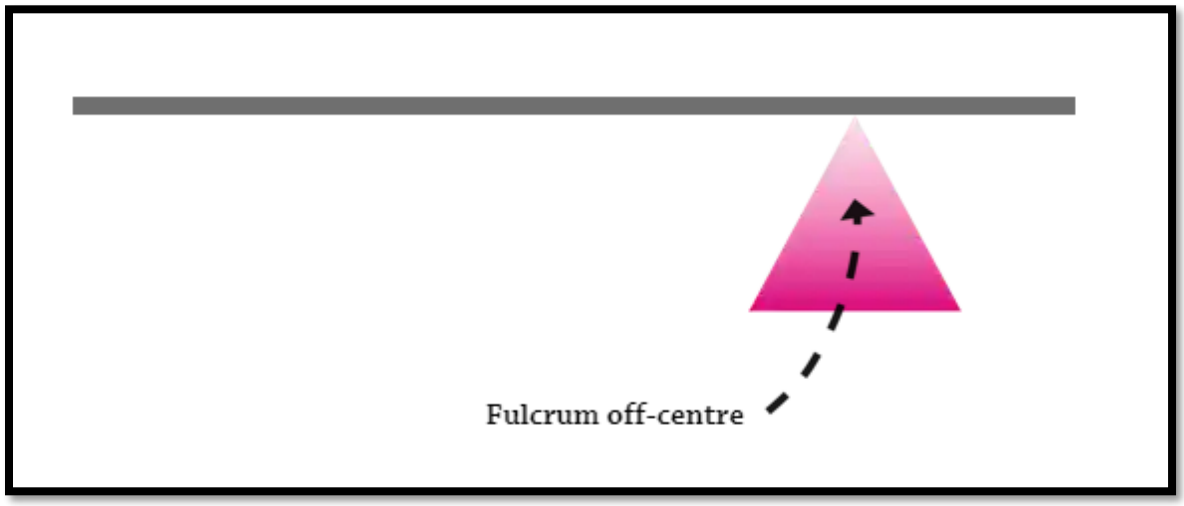


A lever is a long, thin solid balanced on a fulcrum. The best levers are strong, so they do not snap or bend when force is applied.

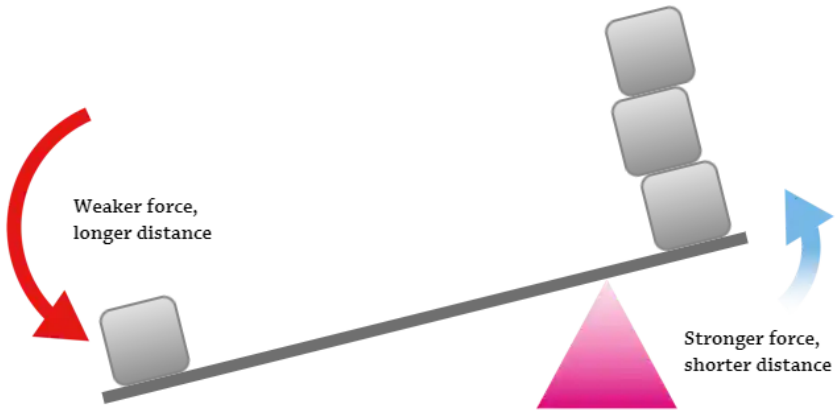


The fulcrum is in the middle of the lever, so any force added at one end will create an equal force at the other end of the lever.


Weight
removed


Fulcrum off-centre

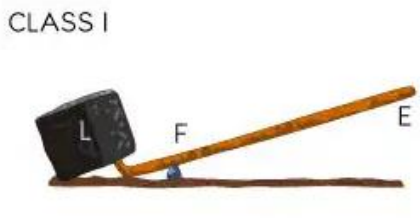
Smaller forces over a longer distance can have more power than larger forces over small distances.



It is easy to push down the end of the lever with one box, because it is over a longer distance.

The parts of the lever are not always in the same arrangement. The load (L), fulcrum (F), and effort (E) may be at different places on the plank. There are three types of levers. These include:

First-Class Lever



First-class levers have the fulcrum between the effort and the load. The mechanical advantage is more if the load is closer to the fulcrum. The beam is braced against a turning point, which enables it to balance and move easily, upwards and downwards. A user places a load at one end of the beam while applying effort on the other end. Pushing at one end of the arm creates a larger force at the other end. Levers are very useful in lifting very heavy loads using less effort. A carjack, seesaw, boat oar, and crowbar are examples of a first-class lever.

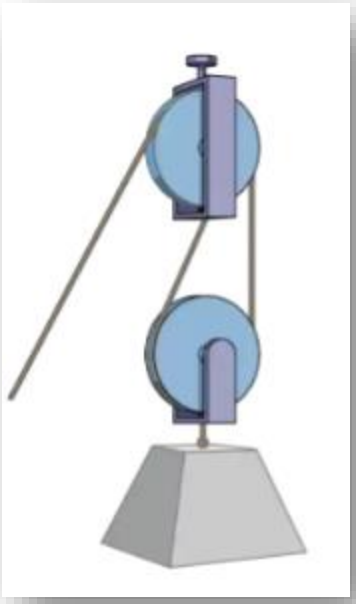
Second Class Lever

In second class levers, the load is between the fulcrum and the effort. The mechanical advantage is more if the load is closer to the fulcrum. Bottle openers and wheelbarrows are some of the examples of second-class levers. A human ankle area is also an example of a second-class lever. When a person stands at tiptoe position, the ball of the foot acts as the fulcrum, the body as the load, and the muscle contraction as the effort.

Third Class Lever

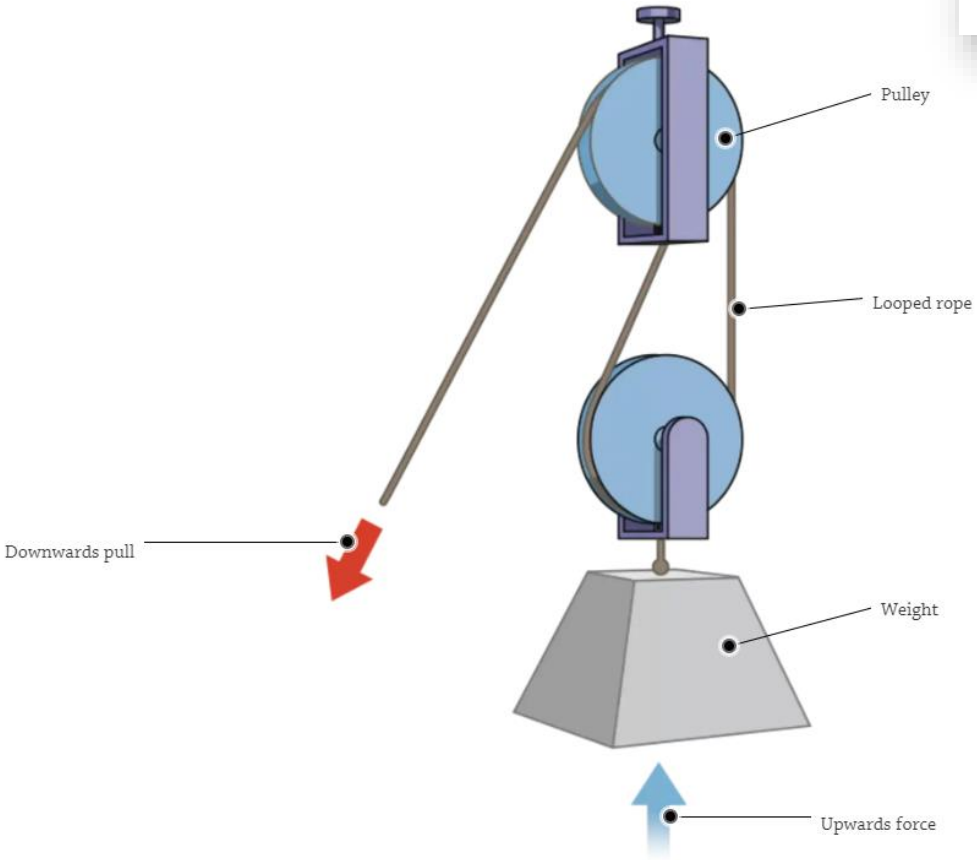
In third-class levers, the effort is usually between the fulcrum and the load. The mechanical advantage is more if the effort is closer to the load. Examples of these levers are a pair of tweezers, a fishing road, a garden shovel, and a broom.

PULLEYS – A pulley is also a simple machine that makes it easy to lift heavy objects. It is a wheel with a groove and a rope in the groove. The groove is important because it helps to keep the rope in place.



Pulleys are made by looping a rope over one or more wheels. 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. Looping the rope over more wheels increases the upward force, making work even easier since the force pulling one side of the rope is increased. Using two wheels means you can lift something twice as heavy using the same force.

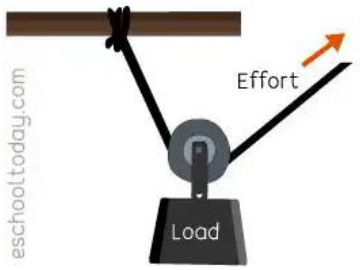
Some of the pulleys we encounter in daily life include a cargo system, a crane, an engine, a flag pole, a bulldozer, and an escalator.



There are three types of pulleys. These include:

Fixed Pulleys
Simple pulleys have their axles fixed in place and cannot be moved. The rope moves in the groove of the pulley, but the wheel is fixed to one spot. The wheel on your school flag pole is a good example.

Movable Pulleys
This type of pulley has a drum that moves as the user is moving the load. A load is attached to the pulley, and both of them can move from place to place. In this type, one end of the rope is attached to a fixed point that does not move. With a movable pulley, you need less effort to lift a load. Can you tell how the movable pulley is similar to the Class Two Lever? Both of them have the load between the effort and the fulcrum!

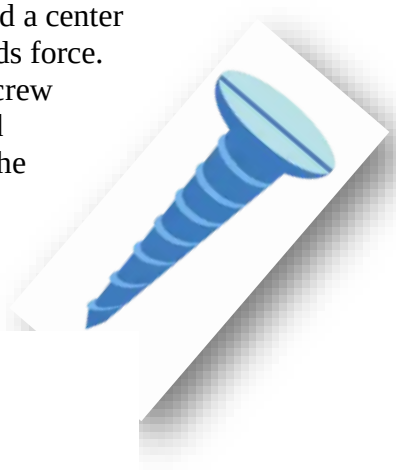


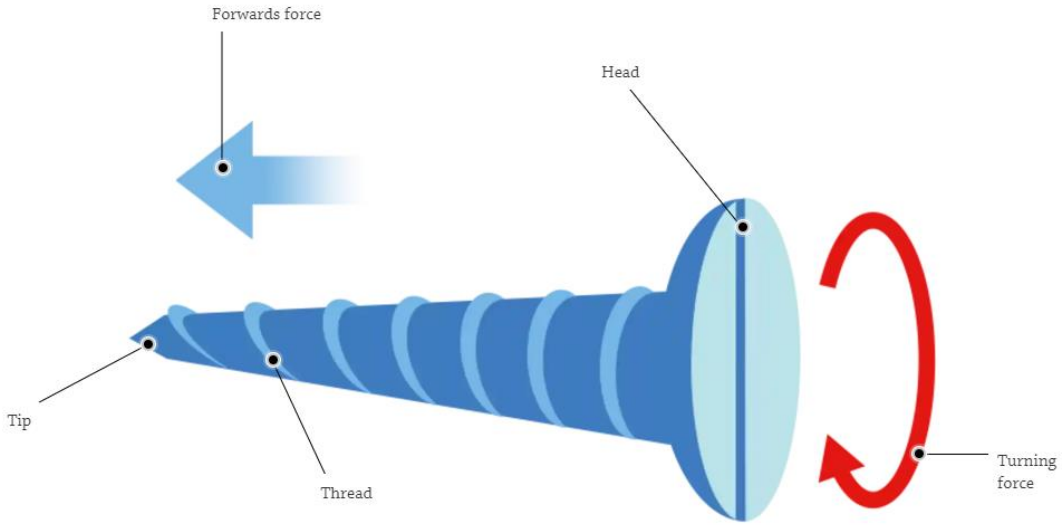
A movable pulley

A well is the most common example of a movable pulley. It works by reducing the amount of force required to lift a load. The load is placed on one side of the pulley, and force is applied on the other side. As the person getting water applies the force, the load goes downwards, creating opposing forces.

Compound System
This is also called a combined pulley. It is a combination of pulleys designed to make the effort less than half of the weight of the load. This kind is common at construction sites where cranes lift very heavy steel and concrete objects. A compound system has both fixed and movable pulleys. The more the number of pulleys a compound pulley has, the easier it gets to lift a load.

SCREWS – A screw can be described as an inclined plane wrapped around a center rod or cylinder. Screws change a gentle turning force into a strong forwards force. It also has ridges around it, known as the threads, which runs around the screw from the wide top to the narrow end. The distance between one thread and the other is usually the same in a screw, and is called a Pitch.. Each time the screw is turned, the thread pulls it a short distance along. The force required to move the screw forward is spread out all along the length of the thread.





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 being that nails don't have threads.

Common types of screws include bolts and drill bits.
A bolt is a kind of screw that 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.

WEDGES – 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)

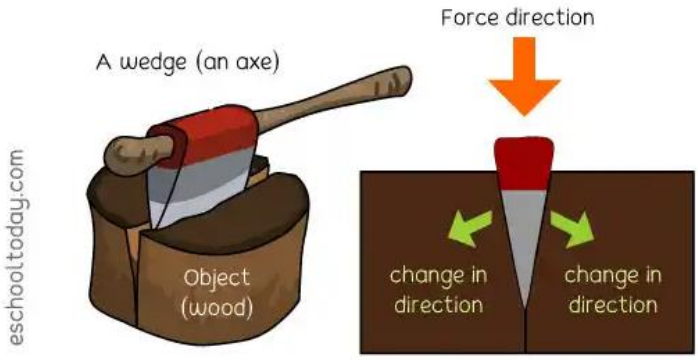
Wedges work by changing direction and force applied to it. For example. A wedge can be used to split material. By placing the thin end of the wedge onto a log, you can hit it with a hammer. The wedge changes the direction of the force and it pushes the log apart.

! Cutting with wedges

Axes use wedges to cut or split wood. The axe head has a wide end where the force is applied, and a thin end that does the cutting. When the axe is swung, the force of the swing comes through the handle to the wide end of the head. The narrow end of the head focusses all of that force into a tiny area, cutting into the wood underneath. The long wooden handle of the axe works as a lever, increasing the force of the swing.

The first machines were wedge-shaped stone axes made by our distant ancestors around 2 million years ago.

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.

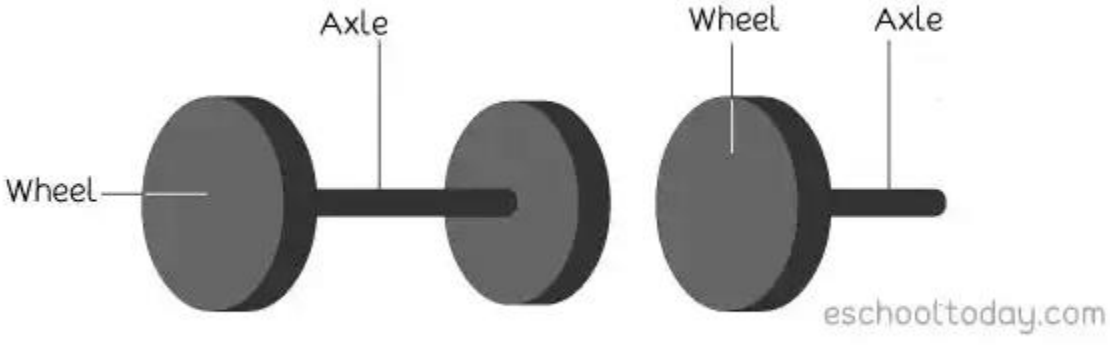


Trade-off
The longer and thinner a wedge is (sharper), the more work it does with little effort. If the wedge is shorter and has a wider angle at the tip, one needs more force to do the work.

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 AXEL – A wheel and axle reduce friction by allowing things to roll, which makes them rub against each other less. It involves two circular objects — a larger disc and a smaller cylinder both joined at the center. The larger disc is called the wheel. The 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.

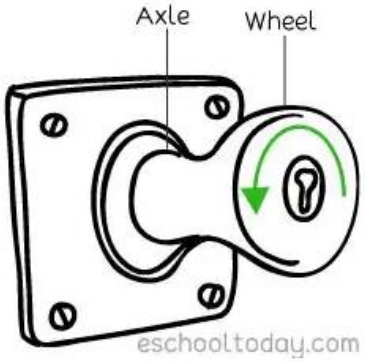


What is a Wheel and Axle Simple Machine?

If you look closely at how a wheel and axle work, you will notice that it is a kind of class one lever. Here, an action on the axle (turning the axle) will cause output at the other end (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 (shaft) greater.



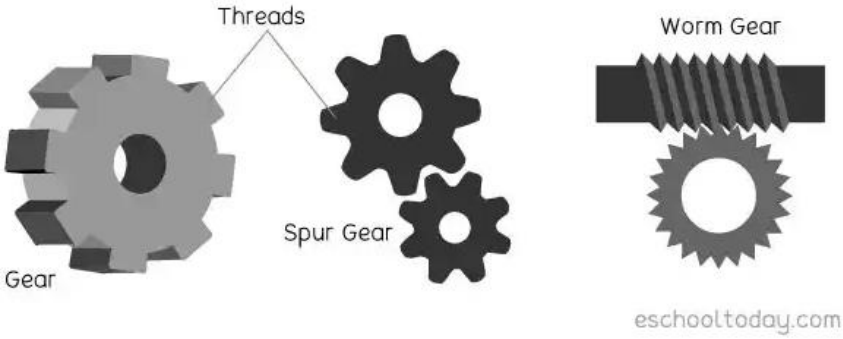
A simple doorknob is another example of the wheel and axle. The locking mechanism of the doorknob is inside of the door and can only be controlled by the knob. Since it will be difficult turning the axle to open the door, we can turn the wheel instead and that does the job for us.

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.

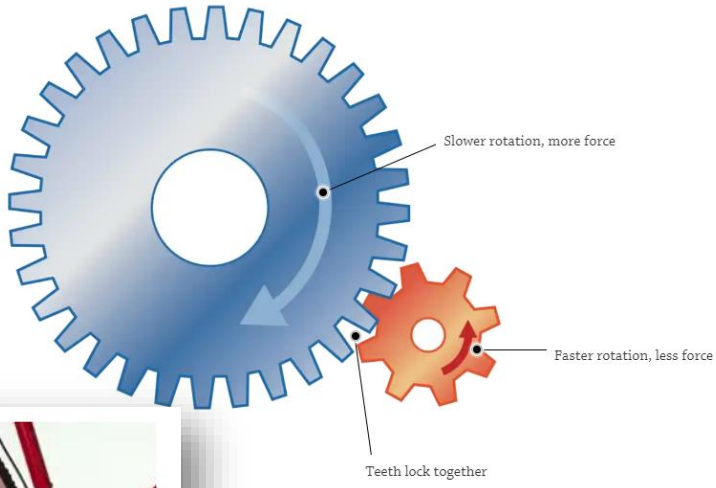
Gears

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.



Types of gears

Gears are wheels with teeth that slot together. When one gear is turned the other one turns as well. If the gears are different sizes, they can be used to increase the power of a turning force. The smaller wheel turns more quickly but with less force, while the bigger one turns more slowly with more force. Cars and bicylces use gears to achieve amazing speeds our bodies could never match without help.

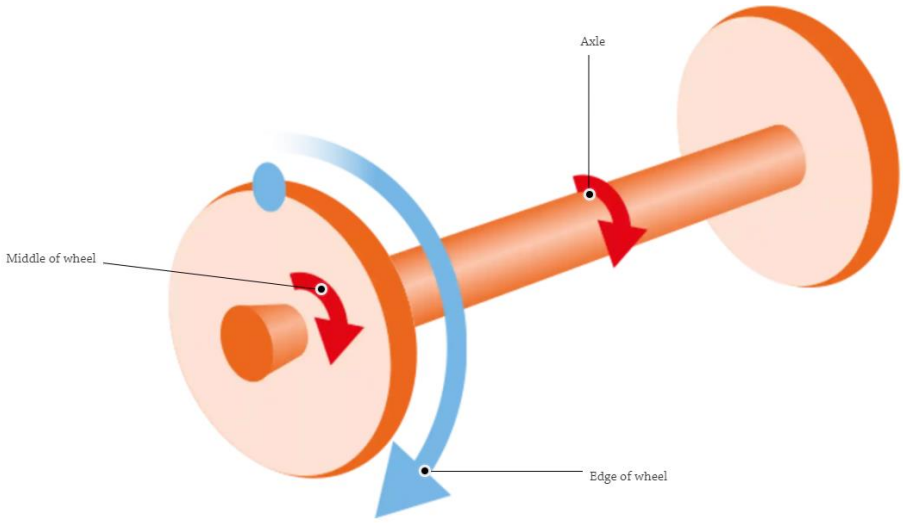


! Bicycle gears

Gears on a bicycle are usually connected by chain, but they work the same way as gears that are touching. The chain transfers the turning force from the pedals to make the wheels go around and move the bike along. The chain can be moved between gears of different sizes, either to increase the speed (for racing) or to increase the force (for climbing steep hills).

A little more information…

WHEELS – Wheels are simple machines for reducing the force of friction. Dragging something over rough ground is hard work, but wheels make it much easier by allowing the object to roll along. Wheels can also be used to help turn something with more force, or help something to turn faster. When the wheel turns, its edge goes around more quickly than the middle. A gentle turning force at the edge of the wheel can be used to make a stronger turning force near the middle of the wheel.



! Driving on wheels

Wheels on cars and lorries are attached to a pole called an axle, which passes through the centre of the wheel. The engine spins the axle round and round, turning the wheel and moving the vehicle along.

Fun Facts about Simple Machines

- Simple machines were first discovered and described by Greek philosopher Archimedes.
- The Egyptians likely used the inclined plane to help build the 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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