

# Forces and Mechanisms

## Forces

A force is a push or a pull that makes something move, change speed or change shape. Forces act in pairs that oppose each other. A force can be either a contact force or a non-contact force.



## Contact forces

A contact force is a force that acts between two objects that touch. Contact forces include:

**friction** A force between two surfaces as they move across each other that always slows an object down.

**air resistance** A frictional force that acts to slow an object's movement when it moves through air.

**water resistance** A frictional force that acts to slow an object's movement when it moves through water.

## Non-contact forces

A non-contact force acts between two objects that do not touch. Non-contact forces include:

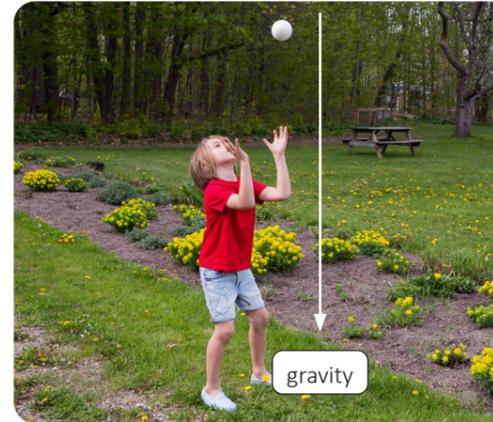
**magnetism** The attraction and repulsion between two magnets or between a magnet and magnetic materials.

**gravitational force** A pulling force between objects that have mass.

## Gravitational force or gravity

All objects have gravity because all objects have mass. Usually, the gravitational force between two objects is very weak because the objects are small. Gravitational force becomes larger as an object's mass increases. Gravity gives an object weight.

Earth's gravity pulls objects towards its centre. Earth's gravitational force is strong because Earth has a large mass. Gravity keeps objects on the surface of the Earth and pulls all unsupported objects to the ground.



The force of gravity is weaker on the Moon than on the Earth because the Moon has less mass. Gravity on the Moon is about one-sixth of that on Earth.

The Sun has a strong gravitational force because its mass is so large. This force keeps the planets in our solar system travelling in a curved path, called an orbit, around the Sun.



## Mass and weight

Many people commonly mix up and misuse the words mass and weight, even though they have different meanings and units of measurement.

**Mass** is the amount of matter that an object or substance contains. It can never be zero and is the same wherever it is, even in space.

Mass is measured in grams (g) or kilograms (kg) using a scale or the kg scale on a force meter.



**Weight** is a measure of gravitational force. The weight of an object can vary depending on where it is. For example, gravitational force on the Moon is less than that on Earth, so an object weighs less on the Moon. The weight of an object could also be zero if there were no gravity acting upon it.

Weight is measured in newtons (N) using a force meter.



## Frictional forces

Friction is in all places where two surfaces meet. It acts in the opposite direction to movement and always slows an object down. The amount of friction depends on the materials from which the surfaces are made. Friction can be increased by adding tread patterns to tyres and the soles of shoes. Friction can be decreased by smoothing surfaces or using a lubricant, such as oil.



## Air resistance

Air resistance is a type of friction that always acts against the direction of movement. It is caused by air particles hitting an object and slowing it down. Objects with a large surface area will hit more particles, and therefore have more air resistance, than objects with a smaller surface area.

### Increasing air resistance

Some objects are designed to increase air resistance. Parachute canopies have a large surface area, which increases air resistance and slows down the parachutist's descent.



### Decreasing air resistance

Some objects are designed to decrease air resistance. This fighter jet has a small surface area and a streamlined shape which decreases air resistance and allows the plane to move quickly through the air.



## Water resistance

Water resistance is another type of friction that always acts against the direction of movement. It is caused by water particles hitting an object and slowing it down. Objects with a large surface area will hit more particles, and therefore have more water resistance, than objects with a smaller surface area.

### Increasing water resistance

Scuba flippers have a large surface area to increase water resistance as the diver pushes against the water to move forward.



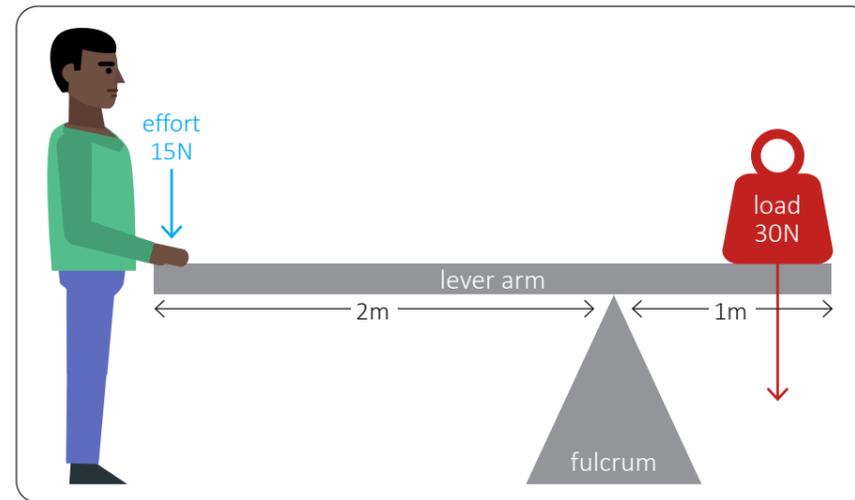
### Decreasing water resistance

The front of a submarine has a small surface area and is streamlined to reduce water resistance.



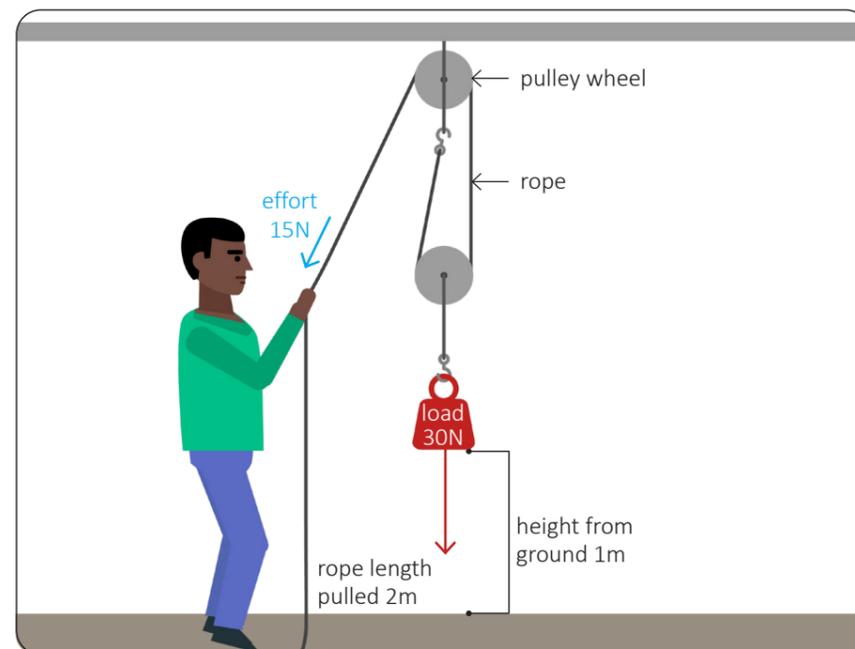
## Levers

Levers are simple machines that can be used to provide a mechanical advantage, so a smaller force can have a greater effect. They consist of a lever arm, a fulcrum, a load to lift and an effort force. Levers make it easier to lift a load. For example if the distance between the fulcrum and the effort is double the distance between the fulcrum and the load, the effort needed will be halved.



## Pulleys

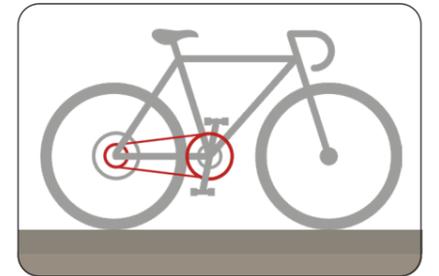
Pulleys are simple machines that can be used to provide a mechanical advantage. They consist of one or more grooved wheels and a rope. Pulleys make it easier to lift a load. For example, when two wheels are used in a pulley, the force needed to lift the load halves. At the same time, the length of rope needed to lift the load 1m off the ground doubles to 2m.



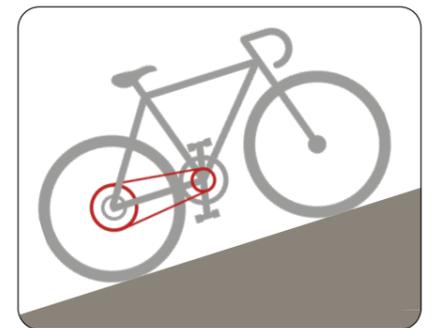
## Gears

Gears are wheels with teeth around their edge. They can be connected directly together, so their teeth mesh and they turn in opposite directions. They can also be connected by a chain to turn in the same direction. Gears of different sizes with different numbers of teeth can create a mechanical advantage. For example, in a mechanism made with a large gear with 12 teeth and a small gear with 6 teeth, the small gear will rotate twice as fast as the large gear but with half the amount of force. Bicycles have different gears. Choosing the right combination of gears can provide a mechanical advantage for the cyclist.

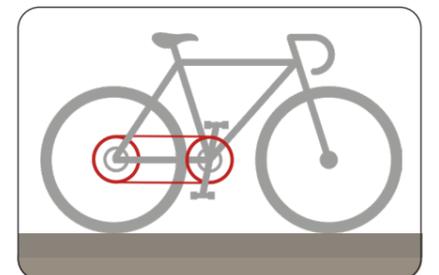
A cyclist can go faster on the flat by using a large gear to pedal slowly attached to a smaller gear at the back, which turns the back wheel quickly.



A cyclist can ride up a hill by using a small gear that is easier to pedal attached to a larger gear, which turns the back wheel slowly but with more force.



Using gears of the same size with the same number of teeth does not give a mechanical advantage because both gears turn with the same force and at the same speed.



## Glossary

<b>mechanical advantage</b>	A measurement of how much a machine multiplies a force, so a smaller force can have a greater effect.
<b>particle</b>	A single piece of matter that is too small to be seen.
<b>streamline</b>	Having a shape that can move quickly and effectively through a liquid or a gas.

