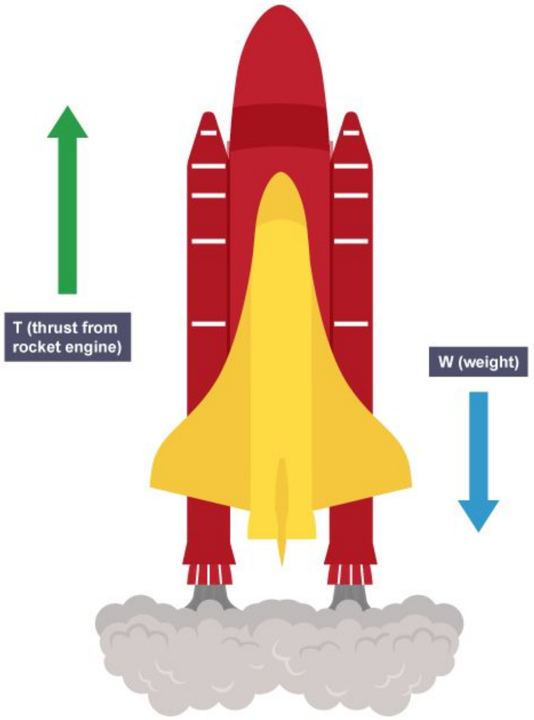
Forces Workshop

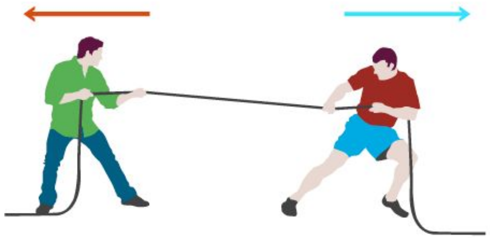
In this workshop we will cover the following:

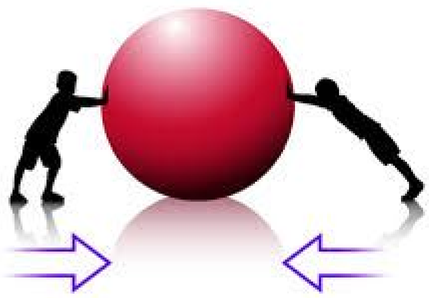
a. Names of Forces
b. Water and Air resistance
c. Upthrust
d. Force arrows
e. Balanced and unbalanced forces
f. Effects of unbalanced forces
g. Work done
h. Levers



Names of Forces

Forces are impossible to see! We can only see the **effects**! Essentially forces are pushes or pulls.





There are a large number of forces in physics, in this workshop we will begin by looking at the most common.

Names of Forces

Forces can be split into two groups; Contact and Non-contact Forces. Below is a list of the most common contact and non-contact forces.

Contact Forces	**Non-Contact Forces**
Friction	Gravitational force
Air resistance	Magnetic force
Water resistance	Static force
Upthrust	
Reaction force	
Thrust	

Contact forces require objects to be touching each other. Non-Contact forces can work at a distance and do not require the objects to touch.

Water and Air Resistance

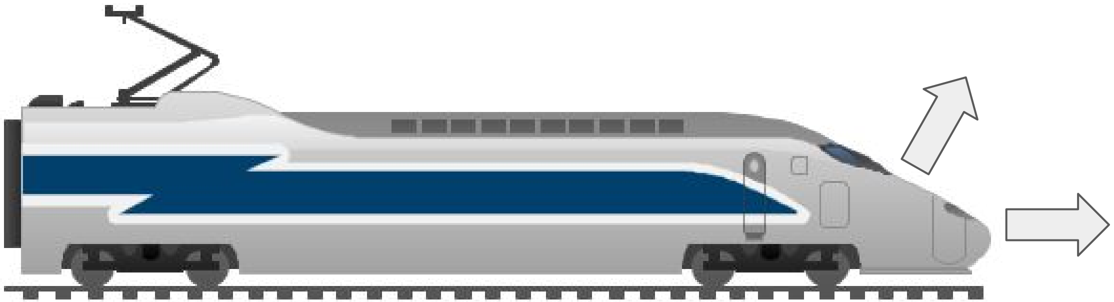
Which of the trains below would be able to travel quickest?

To answer this we need to consider a force called air resistance. Air resistance is caused as an object travels through air.

Water and Air Resistance

As the train moves forward it has to move all the air that is in front of the train out of the way.

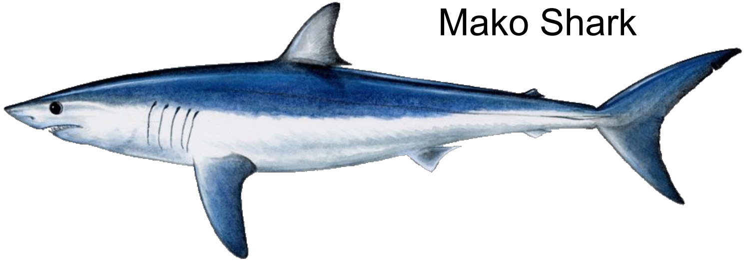
Trains with a blunt front like this tube train can only push the air ahead of it. This is hard work!



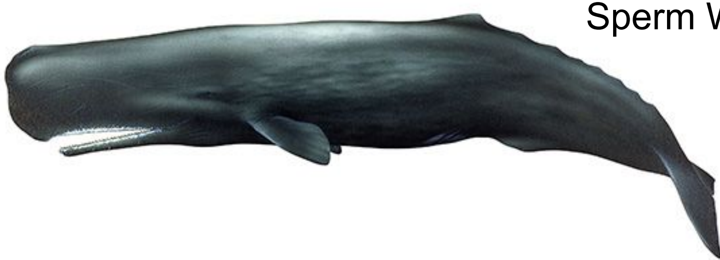
This bullet train has a streamlined shape. This means some air can bounce off upwards, this makes it easier to move!

Water and Air Resistance

The effect of air resistance is even stronger in liquids like water where it is called water resistance. Look at the creatures below. Which do you think are built for speed?

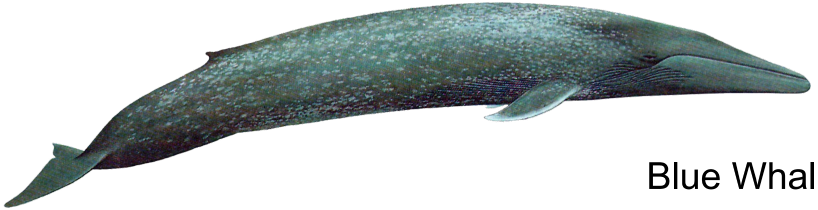


Mako Shark



Sperm Whale

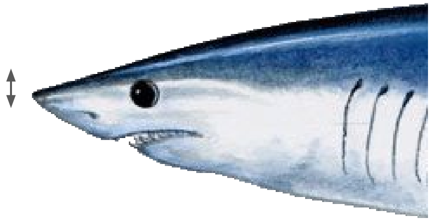
Basking Shark



Blue Whale

Water and Air Resistance

The key to finding out how much water or air resistance an object will experience is the surface area of the front of the creature/object!

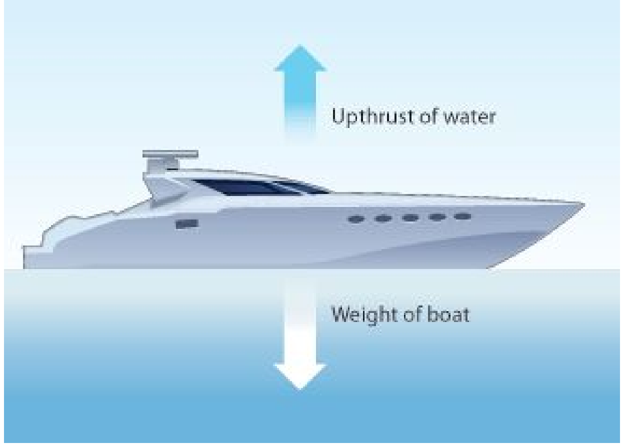


A pointed (streamlined!) nose reduces the surface area and makes it easier for the creature/object to travel at speed in liquids and gases.

Upthrust

Upthrust is a force that acts on objects in fluids (remember that fluids are both liquids and gases - anything that flows!). Upthrust is what allows boats to float and helium balloons to disappear into the sky!

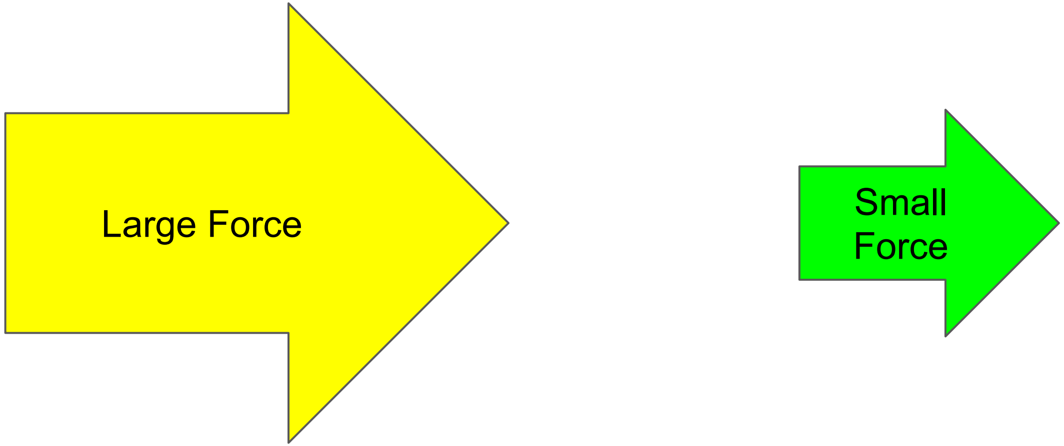
Objects float in fluids (water and air!) when their weight is balanced by the upthrust from the fluid. The object will sink until the weight of the fluid it pushes out of the way is the same as the weight of the object.



Force Arrows

As we can't see forces we use **<u>force arrows</u>** to show the size and direction of a force.

Force arrows can show size…



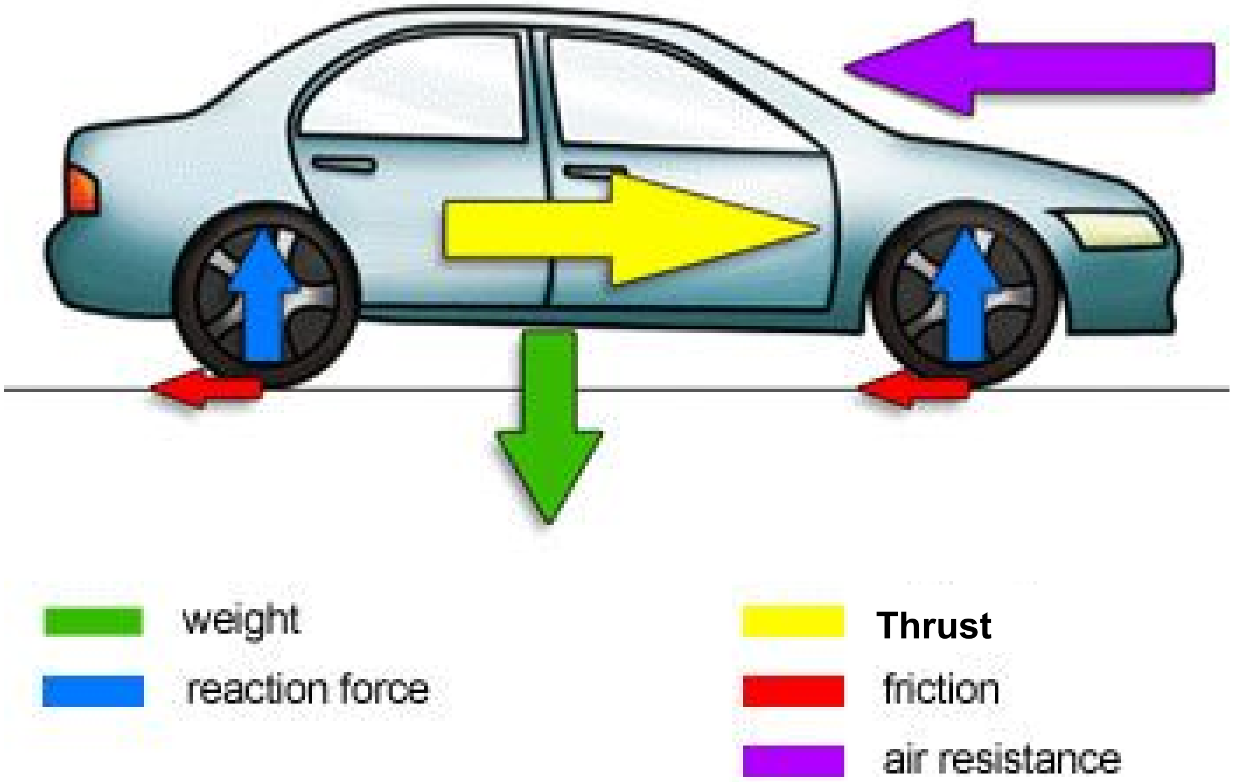
Force Arrows

Force arrows can also show direction.

This diagram shows the forces acting on a car while it is driving along.

Which is the biggest force?

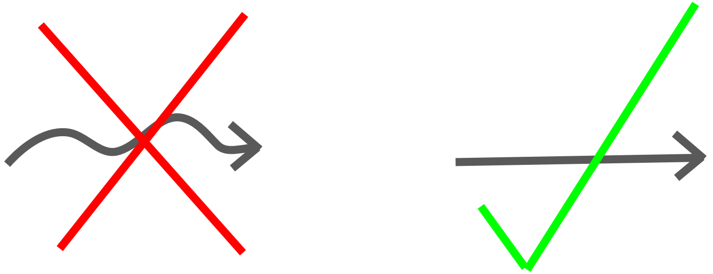
Which direction is friction acting in?



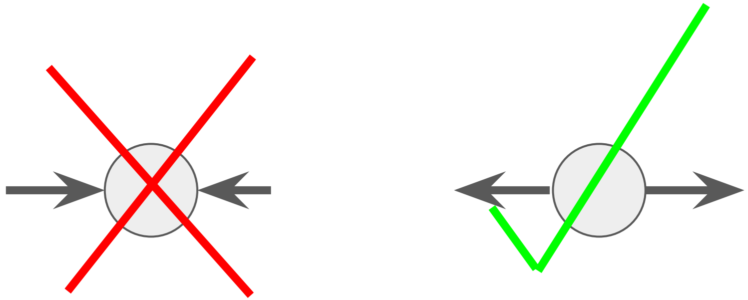
Force Arrows

A couple of things to remember when drawing force arrows.

- Force arrows should always be drawn with a ruler.



- Ideally force arrows should always point away from the object

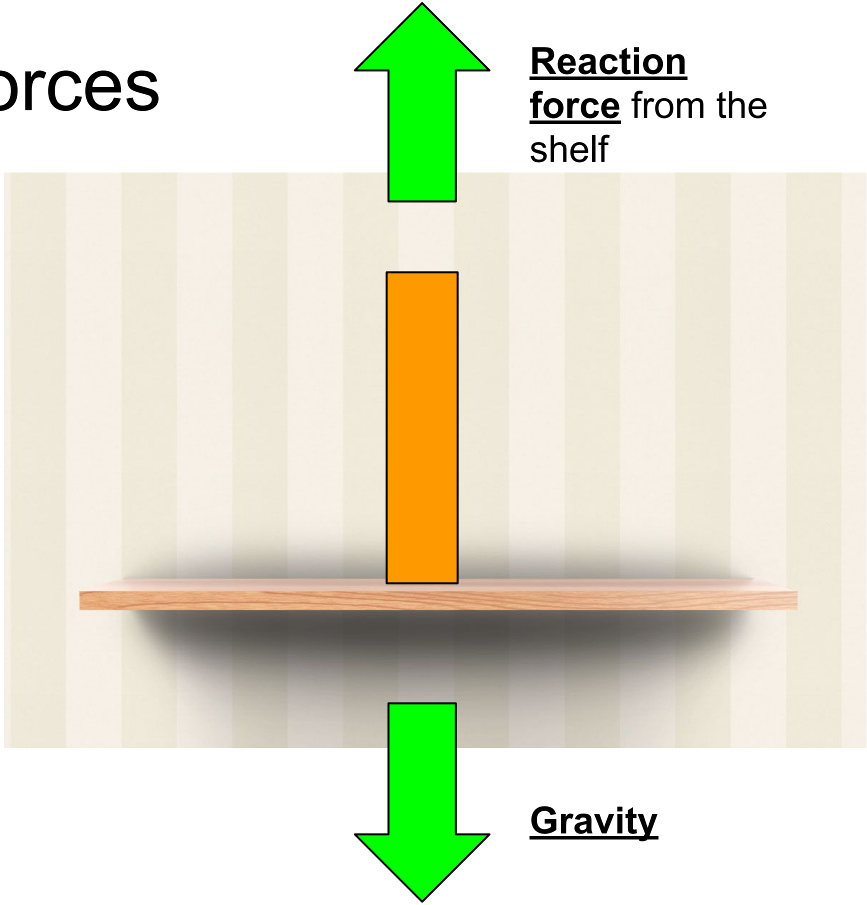


Balanced and Unbalanced forces

If the forces on an object are balanced the object does one of **two** things. It remains stationary (still) or it continues moving at a constant speed.

Consider the example of a book sitting on a shelf.

Notice that the force arrows are the same size. This means the forces are the same size. This book has **balanced** forces acting on it and remains stationary.

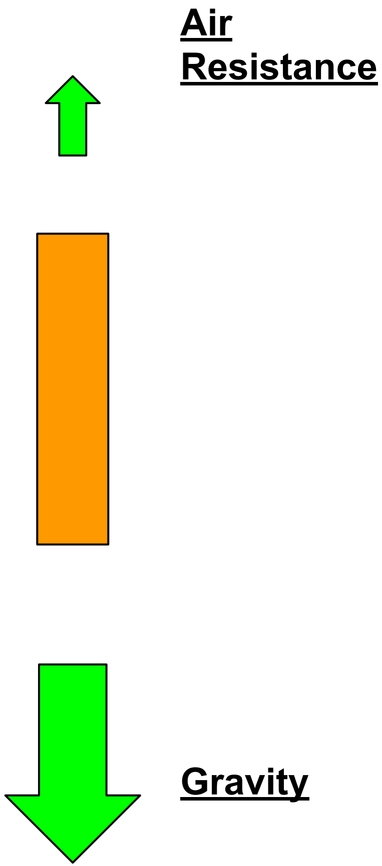


Balanced and Unbalanced forces

Now that the shelf has been removed the **reaction force** from the shelf has gone. The forces are now **unbalanced** and the book begins to **move** (fall).

As soon as an object starts moving in a gas or liquid (air or water!) it experiences resistance. This acts in the opposite direction to travel.

In this case the book experiences **air resistance!**



Balanced and Unbalanced forces

Now let's look at a more complicated example of a skydiver.

As the skydiver is falling the forces are unbalanced they will continue **accelerating** (falling quicker and quicker!)**.**

As they accelerate their speed increases. But air resistance is directly related to speed. As speed increases so does the force of air resistance!

Balanced and Unbalanced forces

Once the skydiver has reached a speed which means the force of air resistance is **balanced** with the force of gravity, he or she stops accelerating (getting quicker).

The skydiver now falls at a **constant speed.**

Balanced and Unbalanced forces

Now the skydiver pulls his or her parachute.

The parachute has a large surface area which increases the force of air resistance massively.

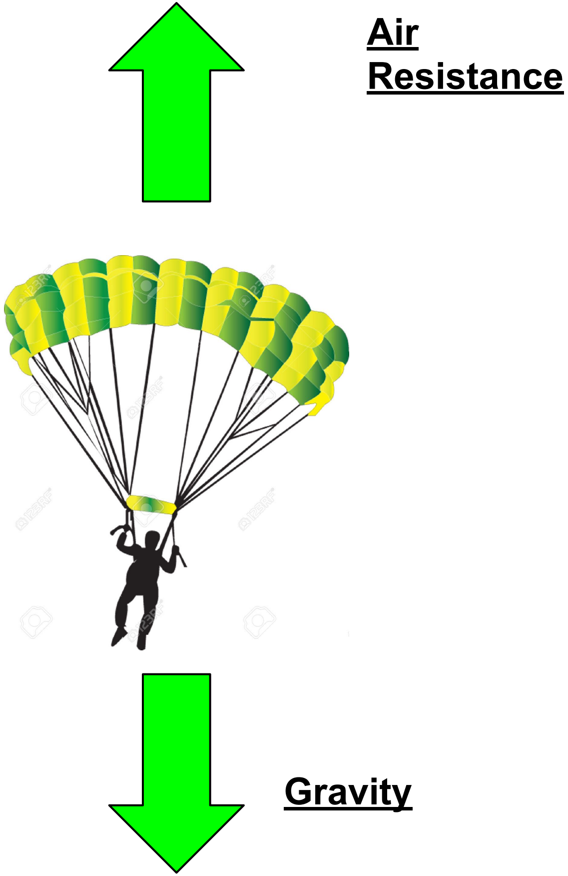
The forces are now **unbalanced** and the skydiver starts to slow down.

Balanced and Unbalanced forces

The skydiver will continue to slow down but as they slow down the air resistance starts to drop (remember that air resistance is linked to speed!).

The skydiver will slow until the forces of air resistance and gravity are **balanced** again.

They will start falling at a **constant speed** again (far slower than without the parachute though!)

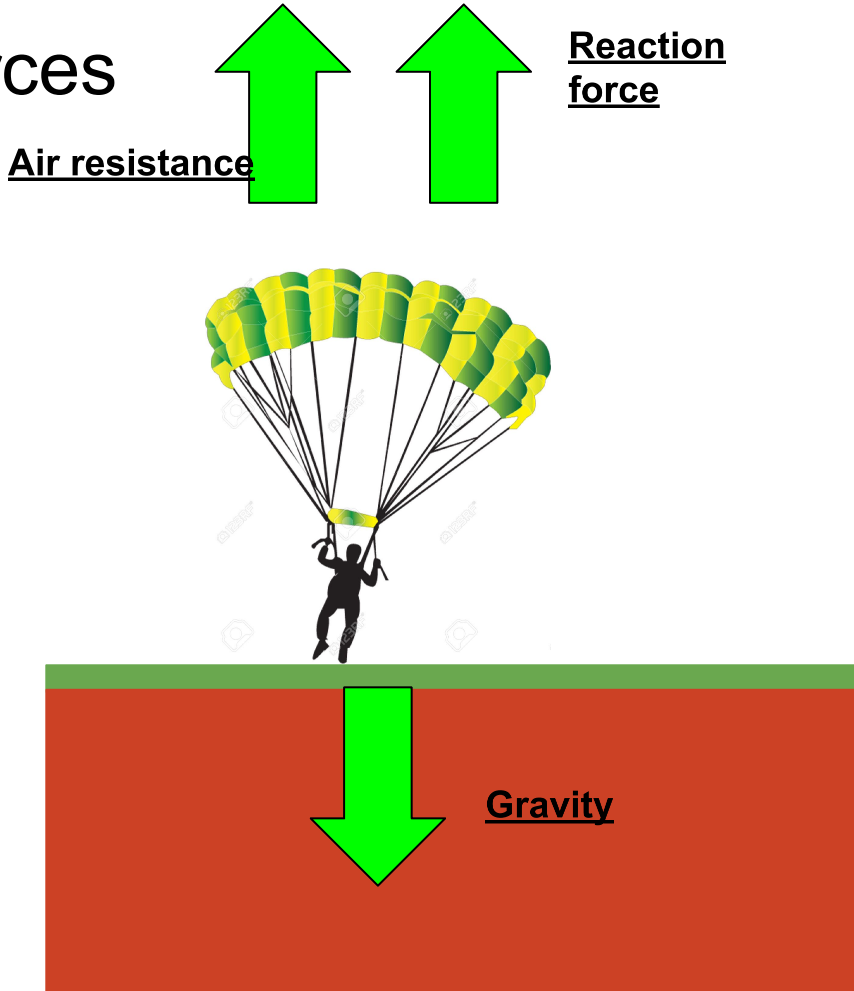


Balanced and Unbalanced forces

Finally the skydiver reaches the ground.

As they touch the ground a new force comes into play… **reaction force**!

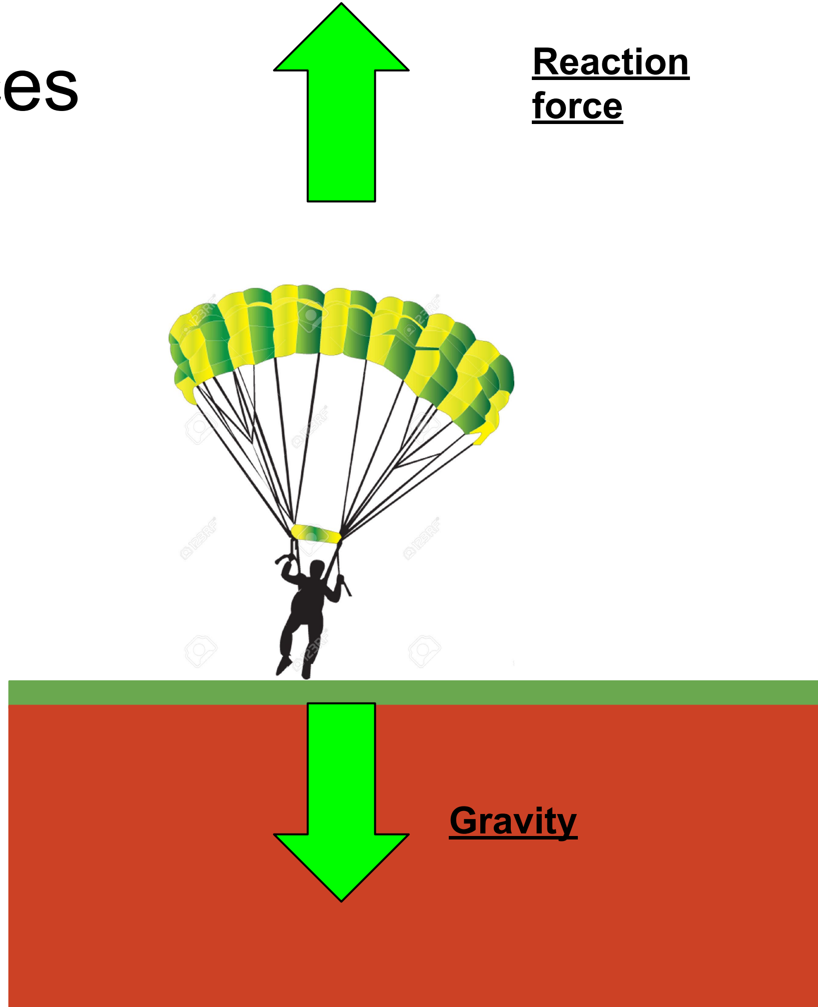
The reaction force massively slows the skydiver down again which reduces the air resistance to zero! But for a time there are two forces acting in opposition to gravity!



Balanced and Unbalanced forces

Now that the skydiver is on the ground and not moving the air resistance disappears.

We are left with just two forces, gravity and reaction force from the ground. These forces are **balanced** and the skydiver is **stationary.**



Effects of Unbalanced forces

Unbalanced forces can have the following effects on an object.

Accelerate (Speed Up)

Deccelerate (Slow down)

Change Direction

Start or Stop moving

Work Done

Consider a car driving along the motorway. The engine is supplying the car with a force and that force is being exerted over a distance (the road!).

This gives us the **work done** by the engine. To calculate work done we use the equation:

Work Done = Force x Distance

E.g For a car with an engine supplying 400N of force over a distance of 1 km (1000m) we calculate work done as:

Work Done = 400N x 1000m = 400,000 Nm (Nm is Newton Meters!)

Note the units! You must always convert distance to meters before calculating!

Work Done

Sometimes you will be asked to calculate the work done by an object but are not given the force and instead are given its mass.

Calculate the work done by gravity on a skydiver who weighs 100kg and falls 2.5km.

First we need to calculate the force…

Force = Mass x acceleration (gravity is an acceleration and is equal to 9.81m/s more usually quoted as 10m/s for ease!)

Therefore: Force = 100kg x 10m/s = 1000N

Work done = 1000N x 2500m = 2,500,000Nm

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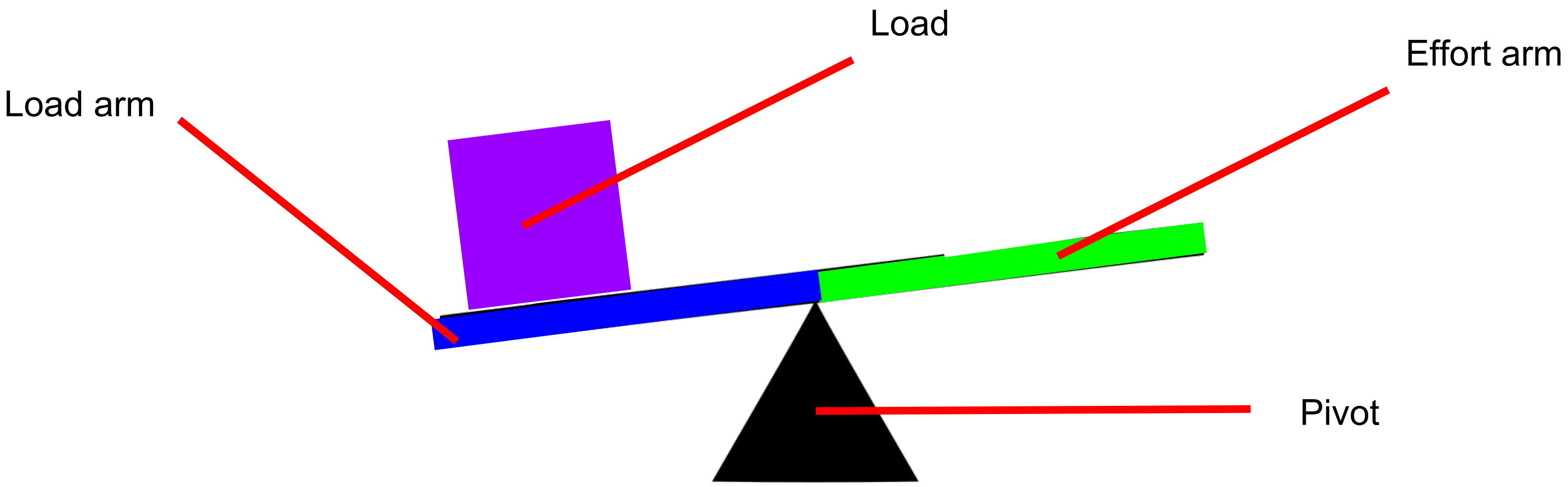
Levers

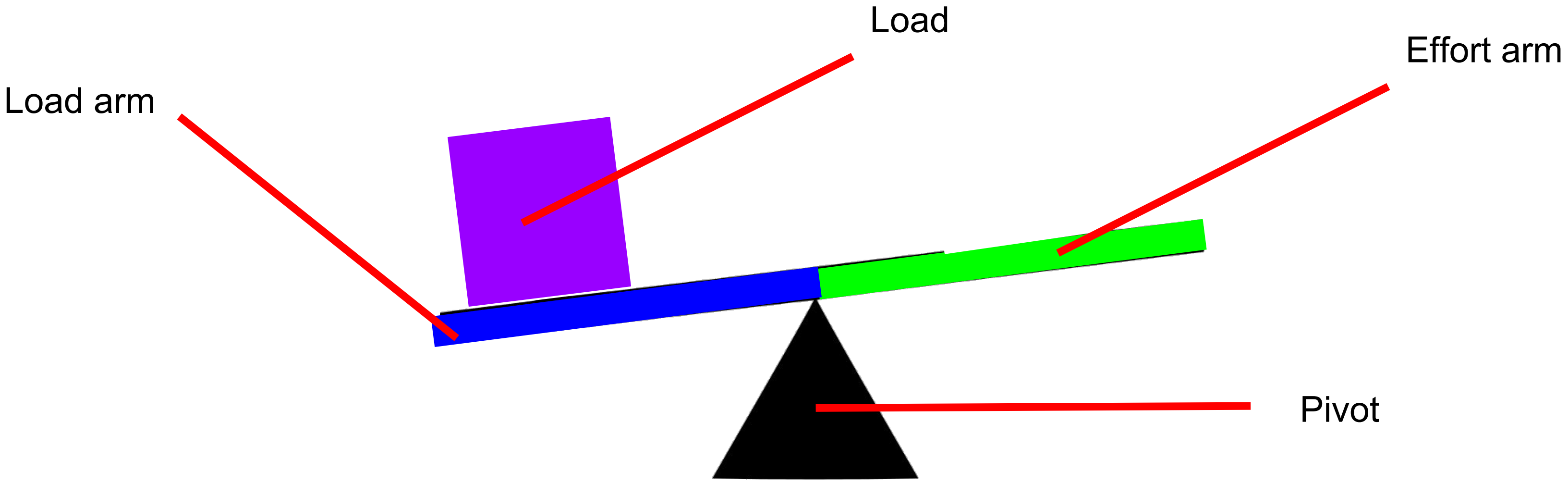
Levers are force multipliers! They make forces bigger, to do this they make a trade; distance for force or visa versa.

Take the example of a seesaw:



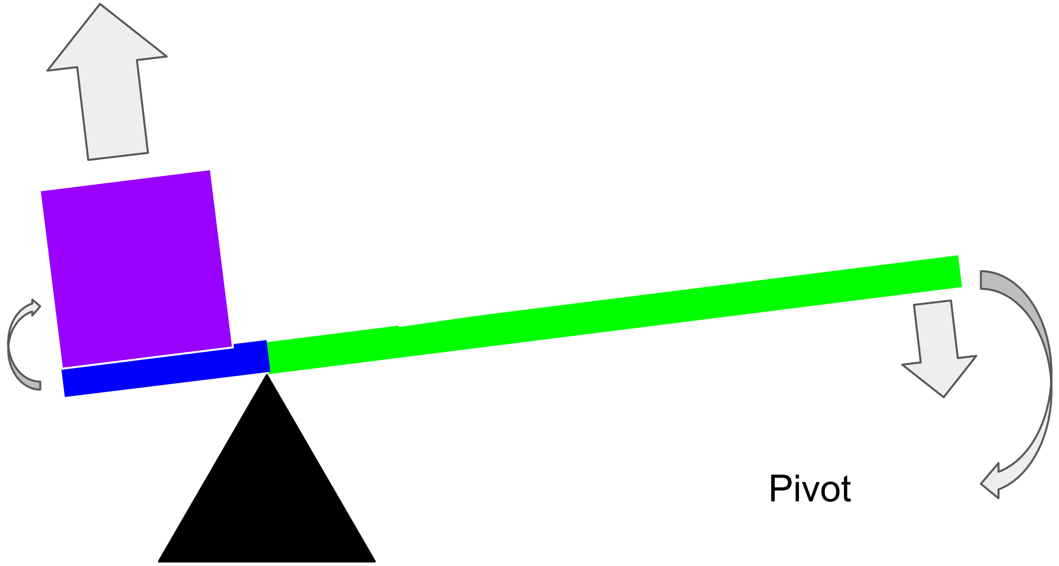
Levers

In the example below the **load arm** and the **effort arm** are the same length. This would mean that there is no force multiplying effect. Effort applied on the effort arm will lift the load on the load arm. Here you are just changing direction (effort applied downwards, load lifted upwards)



Levers

In this example the effort arm is a lot longer than the load arm. A trade is done here, the force arrows show that a smaller force is now needed to lift the block but you can also see that the effort arm has to be moved a larger distance.



Levers

This is an example of how levers can be "**force multipliers**". The force applied to the effort arm is multiplied by the lever and applies a greater force on the block to lift it. Don't forget though that for this to happen a **trade** has to be made! **Force is traded for distance!**