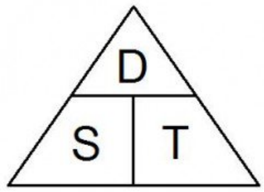
Forces 2

Speed

To measure how fast something is travelling, you need to measure the distance it travels and the time taken. Units for **speed** are **km/h** or **m/s** or **mph**. The unit for speed depends on the units you have used to measure the distance and the time.

Speed is calculated using this formula:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

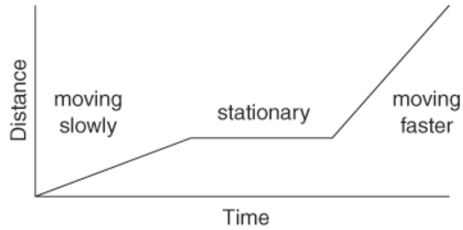


The **mean (average) speed** is the total distance travelled divided by the total time taken.
Actual speeds during a journey can be faster or slower than the mean speed.

A car travelling at 50 km/h overtakes one travelling at 30 km/h. The **relative speed** of the faster car compared to the slower car is 20 km/h.

Distance–time graphs

A journey can be shown on a **distance–time graph**. This graph shows Kieron's journey to school. The steeper the line on the graph, the faster the object or person is moving.



Gradients

The **gradient** of a line on a graph is a measure of how steep the line is. On a distance-time graph, the gradient of a line gives the speed that the object is moving.

Example

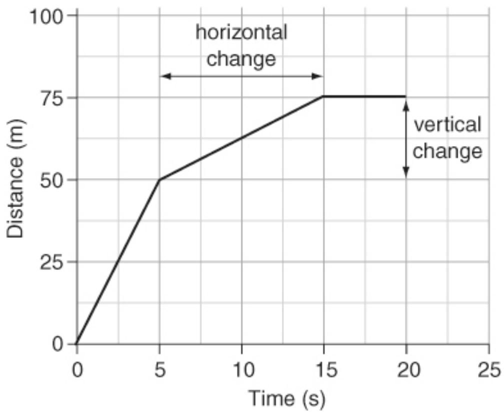
Calculate the speed of the object between 5 and 15 seconds.

$$\text{gradient} = \frac{\text{vertical change (distance moved)}}{\text{horizontal change (time taken)}}$$

$$= \frac{(75\,\text{m} - 50\,\text{m})}{(15\,\text{s} - 5\,\text{s})}$$

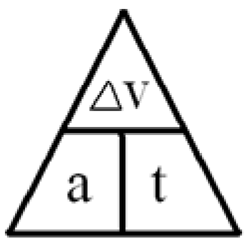
$$= \frac{25\,\text{m}}{10\,\text{s}}$$

$$= 2.5\ \text{m/s}$$



Acceleration

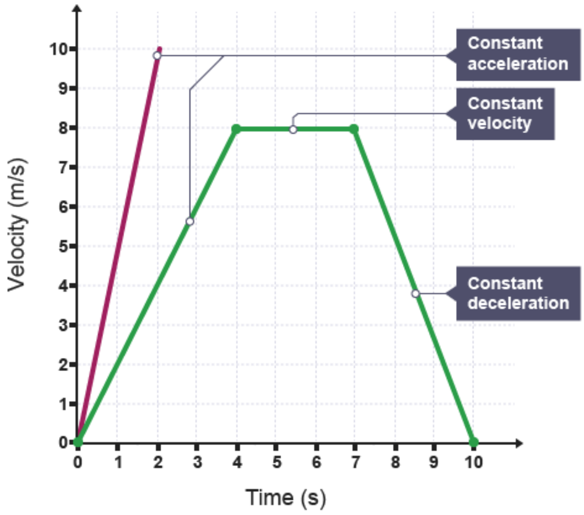
$$\textbf{\textit{Acceleration}} = \frac{\text{change in velocity}}{\text{time taken}}$$



An object that slows down is decelerating.
Near the Earth's surface any object falling freely under gravity has an acceleration of about 9.8 m/s^2.

Velocity-time graphs

The acceleration of an object can be calculated from the gradient of a velocity – time graph.



Momentum

"Momentum is the property of a moving object that quantifies how difficult it is to be stopped".

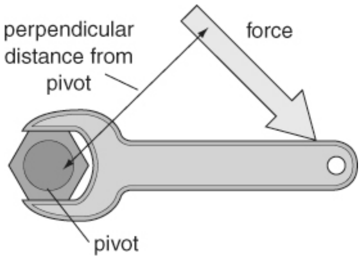
Momentum is calculated using the equation:

Momentum (kgm/s) = mass (kg) x velocity (m/s)

Moments

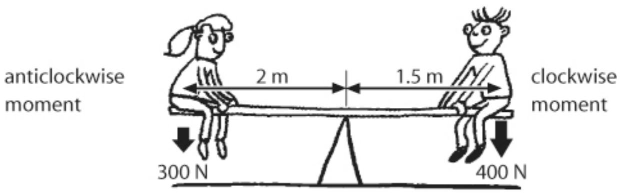
A turning force is called a **moment**. Moments are measured in **newton metres** (**N m**).

moment (in N m) = force (in N) × perpendicular distance from the pivot (m).



The longer the distance the greater the moment. This is why it is easier to turn a long spanner than a short one.

When an object is balanced, the anticlockwise moment is equal to the clockwise moment.



For the seesaw:

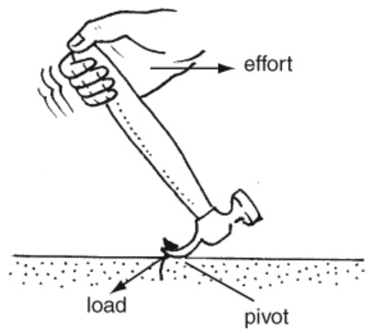
the anticlockwise moment = 300 N × 2 m
= 600 N m
the clockwise moment = 400 N × 1.5 m
= 600 N m

The clockwise and anticlockwise moments are the same, so the seesaw is balanced, or **in equilibrium**.

Levers

Forces can be used to turn objects around **pivots**. A pivot is also known as a **fulcrum**.

Levers can be **force multipliers**, when they increase the force that is put in (the **effort**). They can be **distance multipliers** if they make the **load** move further than the effort. The amount the force or distance is multiplied depends on the distances between the load and the pivot, and the effort and the pivot.



The hammer is acting as a force multiplier.

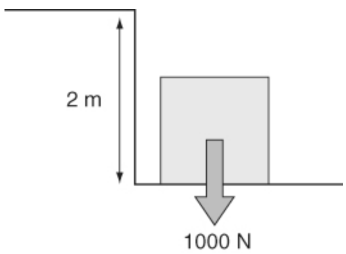
Simple machines

A lever is an example of a simple **machine**. **Ramps** and **pulleys** are simple machines that act as force multipliers.

If a machine makes it possible to lift or move a load using a smaller force, the force has to move through a greater distance. The total amount of energy needed is the same.

The **work done** by moving a load is the same as the energy transferred. Work is done when a force moves through a distance. Work is measured in joules (J).

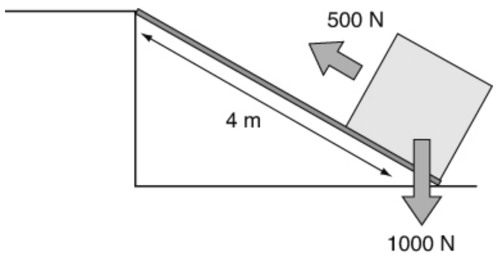
work = force × distance moved in the direction of the force.



The work done to lift the box 2 m is:

work = 1000 N × 2 m

= 2000 J



The ramp makes it possible to move the box using a force of only 500 N, but the box has to be moved 4 m.

work = 500 N × 4 m

= 2000 J.

The box stores the same amount of gravitational potential energy when it is in its final position whichever method is used to lift it. The **law of conservation of energy** means that only this amount of energy is used to lift it.