

Moving things

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:

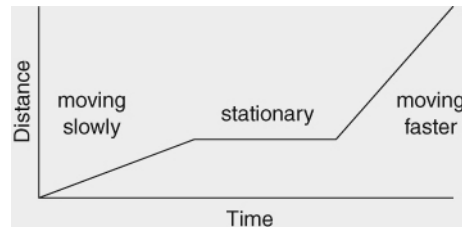
$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

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.



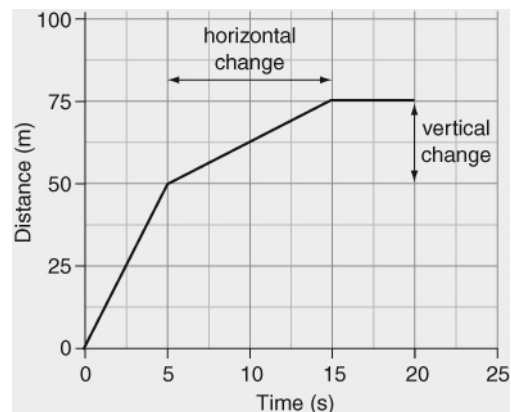
Gradients

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.

$$\begin{aligned} \text{gradient} &= \frac{\text{vertical change (distance moved)}}{\text{horizontal change (time taken)}} \\ &= \frac{(75\text{m} - 50\text{m})}{(15\text{s} - 5\text{s})} \\ &= \frac{25\text{m}}{10\text{s}} \\ &= 2.5\text{ m/s} \end{aligned}$$

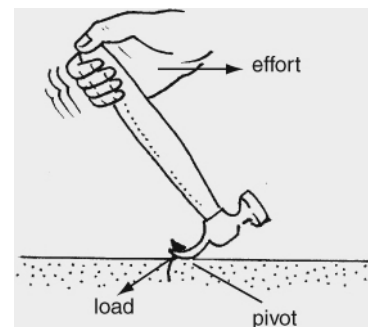


Levers and moments

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

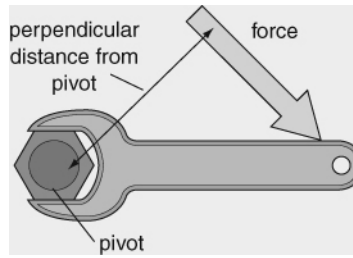
Levers can be **force multipliers**, when they increase the force that is put in (the **effort**). They can be **distance multipliers** if they make the **load** move further than the effort. The amount the force or distance is multiplied depends on the distances between the load and the pivot, and the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

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



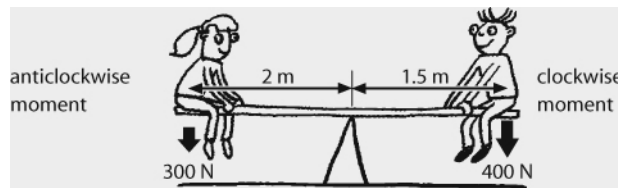
The hammer is acting as a force multiplier.

$$\text{moment (in N m)} = \text{force (in N)} \times \text{perpendicular distance from the pivot (m)}$$



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:

$$\begin{aligned} \text{the anticlockwise moment} &= 300 \text{ N} \times 2 \text{ m} \\ &= 600 \text{ N m} \end{aligned}$$

$$\begin{aligned} \text{the clockwise moment} &= 400 \text{ N} \times 1.5 \text{ m} \\ &= 600 \text{ N m} \end{aligned}$$

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

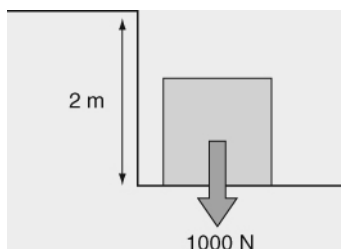
Simple machines

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.

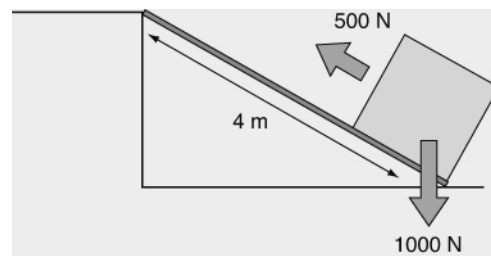
The **work done** by moving a load is the same as the energy transferred. Work is done when a force moves through a distance. Work is measured in joules (J).

$$\text{work} = \text{force} \times \text{distance moved in the direction of the force.}$$



The work done to lift the box 2 m is:

$$\begin{aligned} \text{work} &= 1000 \text{ N} \times 2 \text{ m} \\ &= 2000 \text{ J} \end{aligned}$$



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.

$$\begin{aligned} \text{work} &= 500 \text{ N} \times 4 \text{ m} \\ &= 2000 \text{ J.} \end{aligned}$$

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.