When a force acts on a body **work** is done. Work is a measure of the **energy** transferred. It is always measured in Joules (J).

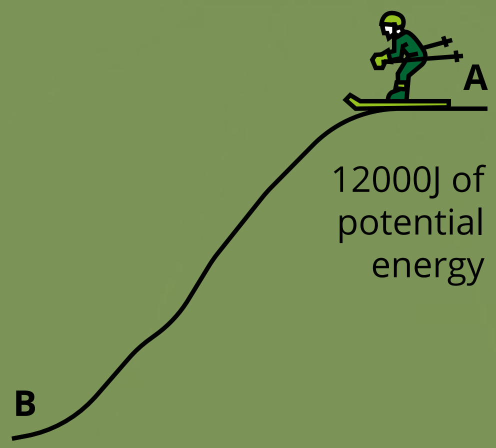
Work is calculated using this equation:

Work = force × distance moved

When work is done, the **total energy in the system must remain the same**. The total energy at the start must equal the total energy at the end of the action. However, the energy **may have changed** from one kind to another.

For example:

1. A skier with 12 000J of **gravitational potential energy** at the top of a slope (A) will have 12000J of **kinetic energy** at the bottom of the slope (B). Gravity will have done 12 000J of work to transfer the potential energy to kinetic energy.

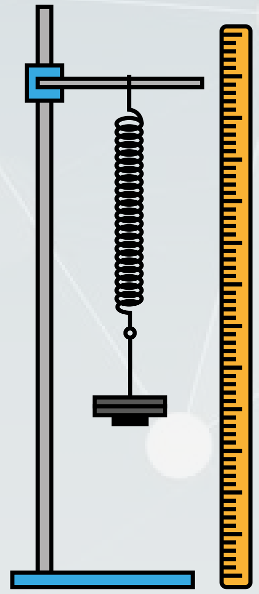


2. A stretched slingshot stores 2J of **elastic potential energy**, when released the force of the rubber changing shape does work on the ball and transfers 2J **of kinetic energy** to the ball.

Putting a **force** on a spring will cause it to stretch. The amount it will stretch, the **extension**, for a given force depends on the spring itself. Each spring will have a different **spring constant** which will determine how much force is required to stretch a spring.

Using this equation, you can calculate the spring constant.

force = spring constant × extension



In most cases the transfer of energy is not efficient. **Some energy is lost due to the work done by friction**. The skier in example 1 above will likely only have 80000J by the bottom of the slope (B). This means that frictional forces will have done 40 000J of work on the skier as they travelled down the slope.

Remember the **total energy in the system must stay the same**; if there is less energy at the end than at the start, some must have been lost as heat.

Car efficiency

The efficiency of cars is an important area of development. **Cars are being made more efficient in order to reduce greenhouse gases and waste less energy.**

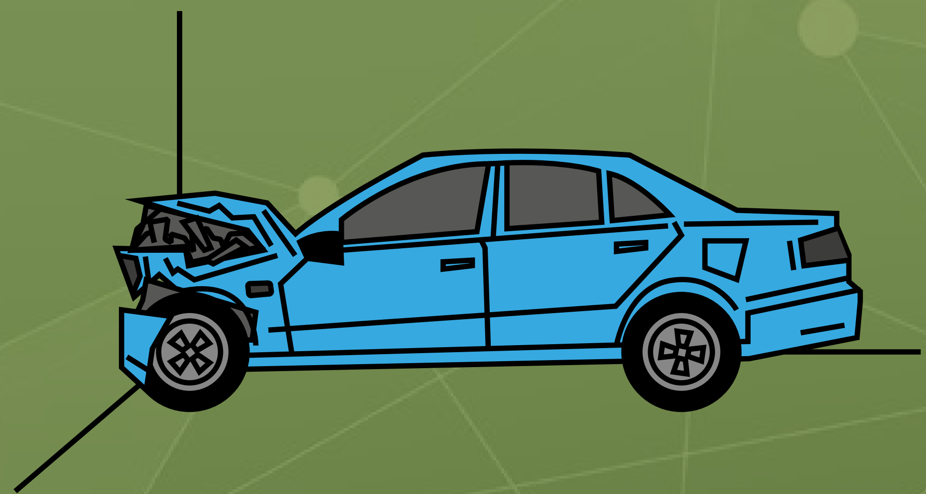
They do this by reducing losses in the car, for example:

- **Start stop systems** to reduce waste whilst stationary
- **Lighter materials** to reduce the mass of the car
- More **streamlined** shapes to reduce the work done by frictional forces on the car
- Ensuring **correctly inflated tyres** to reduce the work done by frictional forces (often done by using a sensor to alert the driver if the tyres are not correctly inflated).

Car Safety Features

Modern cars have built in features to reduce the forces acting on passengers in a collision. These include **air bags** and **crumple zones**. These features both change shape during a collision, this allows the **work** to reduce the **kinetic energy** of the passengers to be done over a **longer distance**.

The longer the distance the work is done over, the smaller the force on the passengers will be.



When calculating energy, the following equations are used:

$$\text{kinetic energy} = \frac{\text{mass} \times \text{velocity}^2}{2}$$

Only on higher tier questions will you need to use these equations. Foundation tier questions will expect you to be able to calculate the energy at the start and at the end and recognise if any work has been done because of friction by calculating any losses.

gravitational potential energy = mass × gravitational field strength × change in height

Energy stored in a spring = the area under the force extension graph

This is easier to calculate for a linear graph using, $W = \frac{1}{2}Fx$ where F is the force and x is the extension