Types of Energy Transfers

Energy

Energy is needed for us to do work. Energy is measured in Joules, J or kilojoules, kJ.

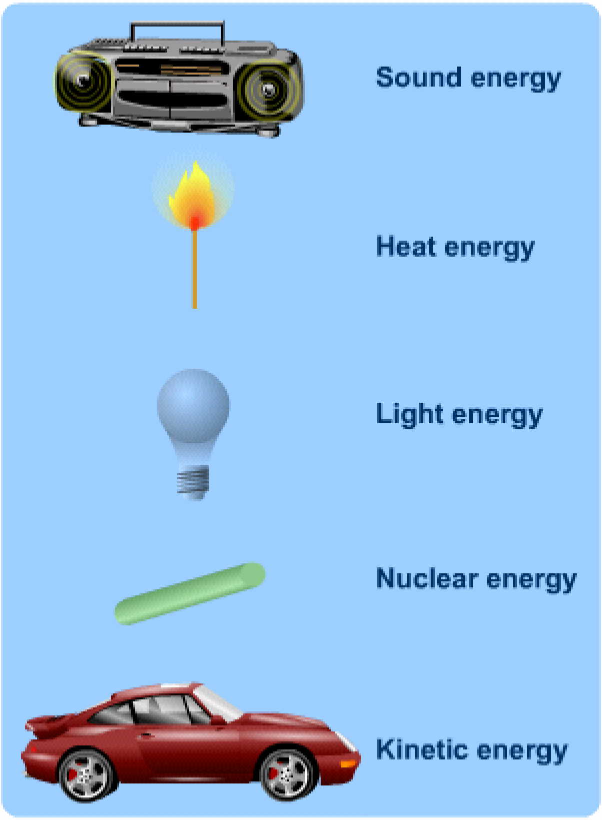
Many scientists believe that there is a certain amount of energy in the universe. As energy cannot be made this energy is just constantly moving around the universe being changed into different forms.

The Earth receives almost all its energy from the sun, but much of it leaves the Earth's atmosphere again and is lost in space.

Types of energy

Although energy cannot be made or destroyed it can be changed into different forms.

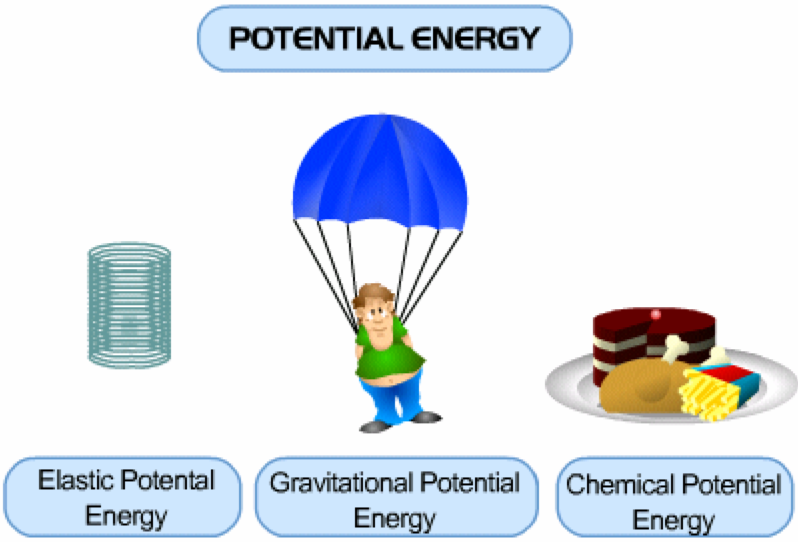
There are many types of energy, but the ones listed below are the most common:



Kinetic energy is a more scientific name for movement energy.

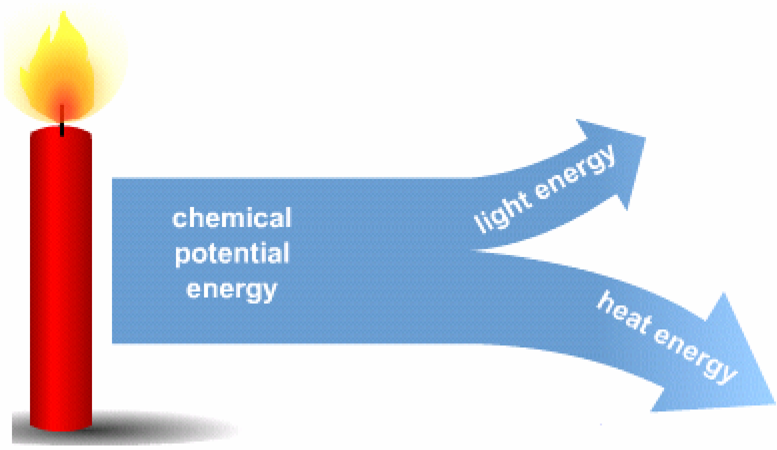
Potential energy is a more scientific name for stored energy.

Potential energy can be divided into three types:



Changing energy

There are many different ways for energy to change its form. **We use Sankey Diagrams to show energy transfers:**



The bigger the arrow is the larger the amount of that type of energy.

In the following diagram drag the correct energy labels to the appropriate arrows.

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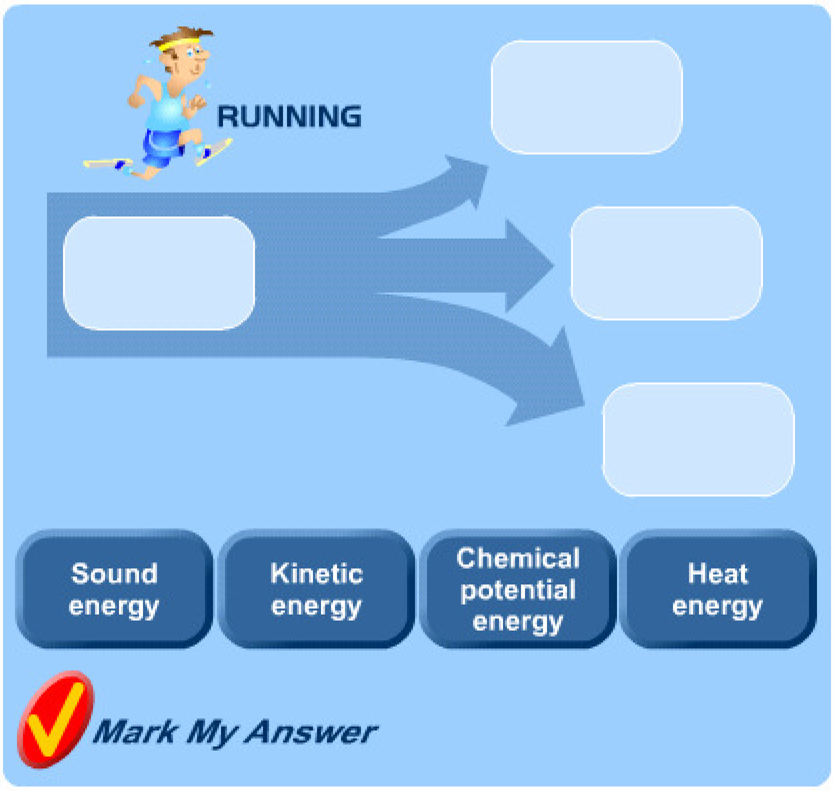


Values for energy are often added to the diagrams.

Always make sure that the total amount of energy coming out is equal to the energy put in!

How Does Heat Energy Move?

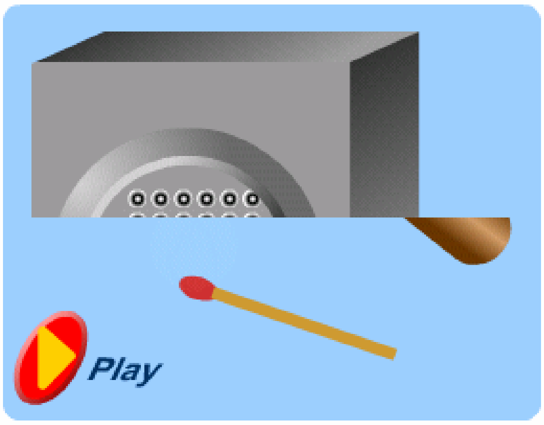
Hot objects have heat energy. **Heat energy always moves from something hot to something colder.** There is no such thing as cold energy, so an object can only get colder by heat energy moving away from it.

There are three ways that heat energy can move:

1. Conduction.
2. Convection.
3. Radiation.

Conduction

When you first pour boiling water onto a Pot Noodle, the plastic container feels cool on the outside. Soon, the heat energy has worked its way through the plastic and the container starts to feel hot on the outside. Heat energy has travelled through the solid plastic container. **This process is called conduction.**



Atoms in a substance are always vibrating. If the substance gets hotter, the atoms vibrate more. The heat energy is given to the atoms, which makes them move about faster. **Note:** the atoms don't swap places, or move around they just vibrate more on the spot.

Have you ever danced next to someone really energetic? If so, you know that it makes you have to move about more – often just to get out of the way! It is like that for atoms passing heat energy on to each other.

Solids are better at conducting than liquids and gases because the atoms are closer together. If the atoms are too spaced out it makes it harder for the atoms to pass the energy along.

Metals are the best solids for conducting heat energy. In metals, there are free electrons that can move through the metal. These electrons are able to move from hot parts of the metal to colder parts, taking the heat energy with them. This is called **electron diffusion.**

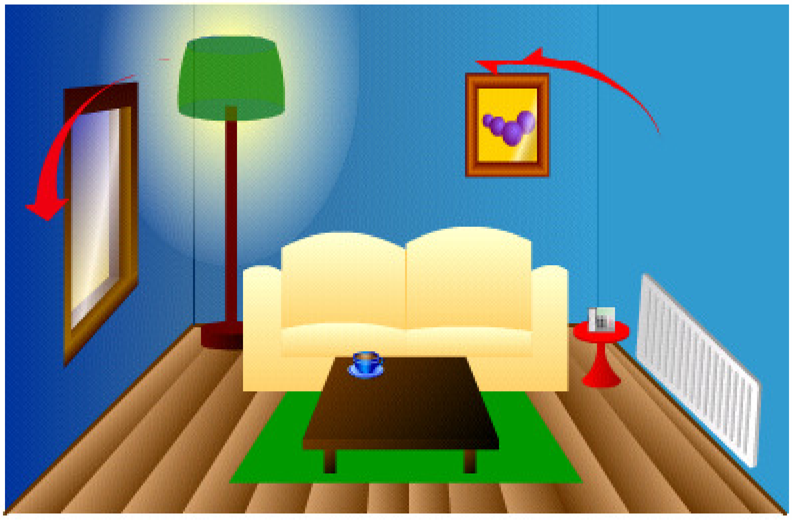
The poorest conductors are gases as their molecules are too far apart to affect each other much. This means that air is a terrible conductor of heat energy.

Convection

Hot air rises in cold air. Hot water rises in cold water. This way of moving energy is called convection. When hot air rises, colder air has to move in to replace it. When hot water rises in a cup, colder water sinks to replace it.

This movement of a liquid or gas is called a **convection current**.

Convection cannot happen in solids, as the atoms aren't able to move around.

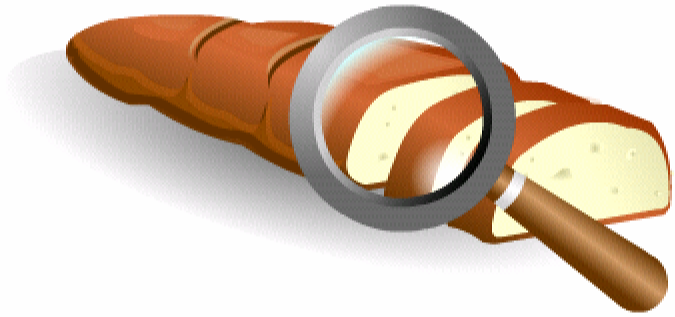


When a liquid or gas heats up, the particles move around more. This makes the particles spread out, so they have more room to move. This lowers the **density** of the substance. The hotter it gets, the lower the density goes. It is this lower density that makes the hotter substance rise. The cooler substance has a higher density, which makes it sink.

Radiation

"How to toast bread!" When a piece of bread is put in a toaster the wires inside the toaster glow red hot on either side of the bread.

How does the heat energy get to the bread?



Is it by conduction?

No, the heat energy cannot conduct through the air to the bread because air is a very bad conductor.

Is it by convection?

No, hardly any of the heat energy could have travelled to the bread by convection, as the hot air particles would rise out of the toaster.

The heat energy must have reached the toast some other way. It travelled as radiated heat. This heat energy movement is sometimes called heat waves, but strictly speaking, it is **infrared radiation**.

Hot objects radiate heat to their colder surroundings. The weird thing is that the surface colour of an object makes a difference.

Black and dull surfaces emit (give out) and absorb radiation well.

White and shiny surfaces do not emit radiation well and reflect radiation instead of absorbing it.

Which of these surfaces is best at emitting radiation?

Put them in order of best to worst:

Marathon runners are wrapped in foil blankets at the end of the race. The shiny surface is a poor emitter of radiation and so prevents them losing too much precious body heat.

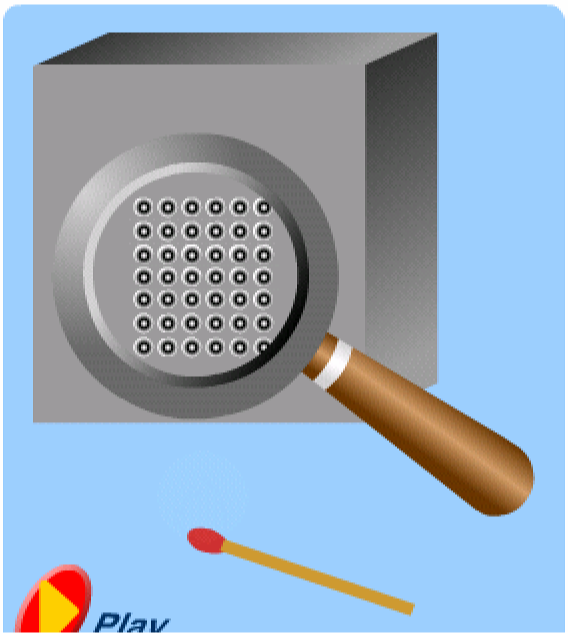
So why do we paint radiators white so often?

I guess people think it looks better.

Which of these surfaces is best at absorbing radiation?

Put them in order of best to worst:

Solar panels are always coloured black. They then absorb the maximum amount of the Sun's energy. This is very important considering the amount of sun we get in the UK. Wearing white in the summer should, in theory, be cooler than wearing black, as more of the incoming heat is reflected away.



How Can We Stop Heat Moving?

Insulation

If your house has a roof space, then it probably has insulation in it. That insulation is a thick layer of fibreglass. It's actually the air in between the fibreglass that makes it a good insulator.

Air is a very bad conductor. Hardly any heat energy can conduct through the trapped air in the fibreglass.

If air is so good why doesn't it work on its own?

Well, the air can **convect** the heat energy away from the house if it is able to move. If the air is trapped in small spaces between the fibres in the fibreglass it can't move so it doesn't convect the heat energy.

Many insulators work because they contain trapped air.

Ways to save energy in the home

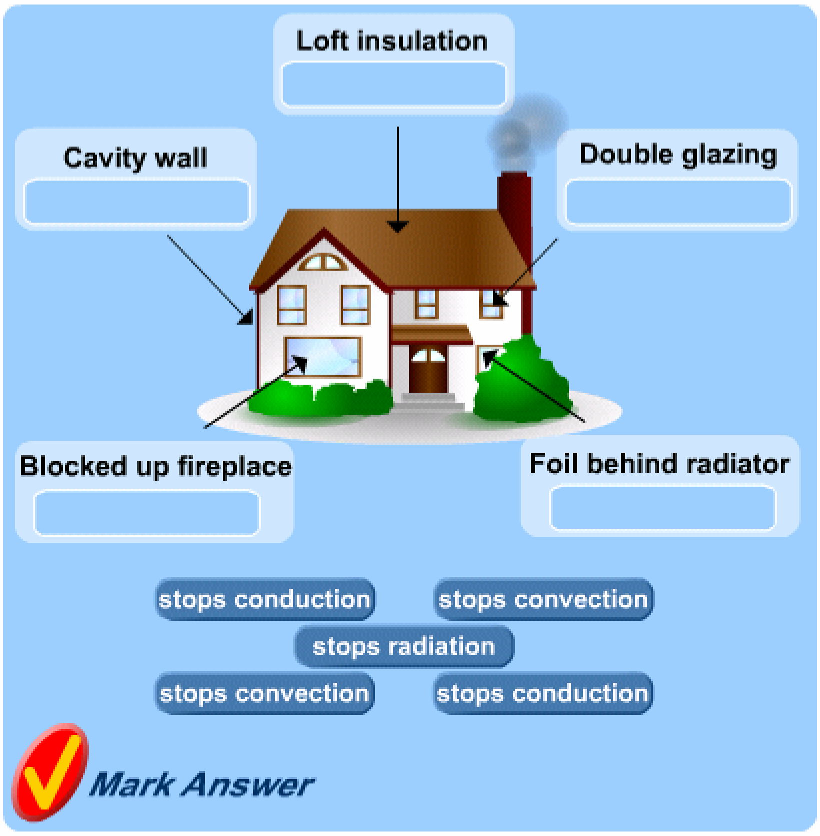
There are two real reasons for reducing heat losses from a home:

1. Saving energy means that less energy needs to be produced, so there will be less damage to the environment. (Think about the pollution from a coal-fired power station.)
2. Saving energy means using less energy so it costs less to heat the house. It can cost hundreds of pounds a year to heat a family house!

Obviously it also costs money to install (put in) insulators and other energy-saving devices. The **payback time** is how long it takes for the savings to cover the cost of installation.

Each method has to stop either conduction, convection, radiation, or any combination of them.

See if you can identify how each method of insulation saves energy in the home, by dragging the coloured boxes into the correct place:



Of course you can do other things: Use low energy light bulbs, turn down heating thermostats, and fit draught excluders, for example.

Non-Renewable Energy Sources

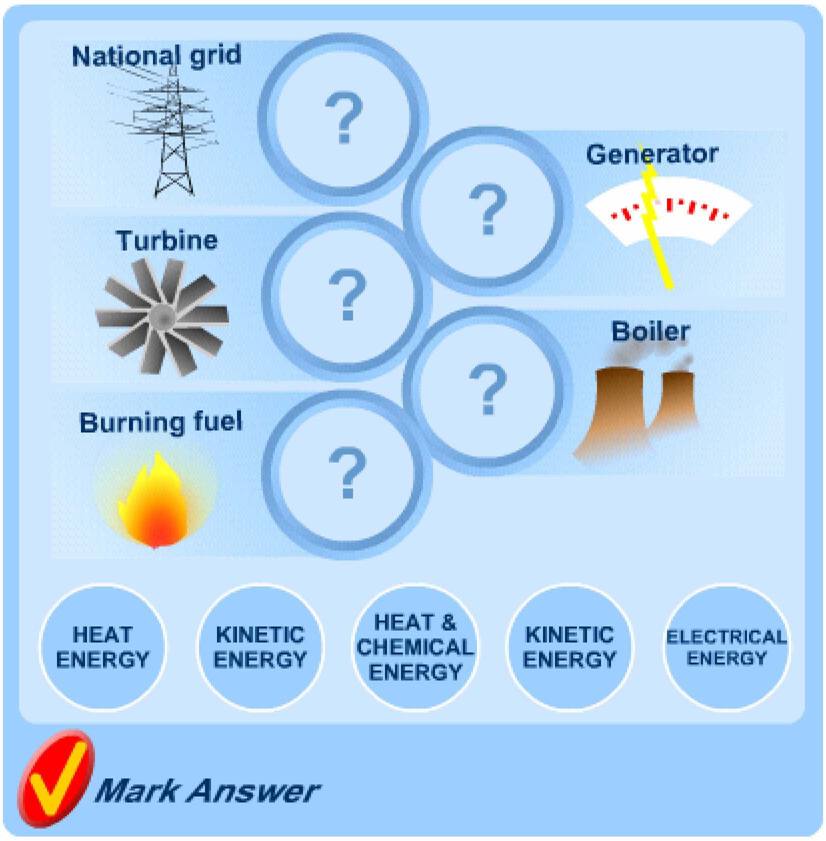
Generating electricity in power stations

All power stations use a similar process to produce electricity.

1. Fuel is used to produce heat energy.
2. The heat energy heats water and turns it into steam.
3. The steam is pushed at high pressure along pipes to the turbines.
4. The steam makes the turbines spin, turning a generator which then produces electricity.

The electricity is then supplied to houses, factories and schools via the national grid.

Drag the correct form of energy directly onto the actual source of the energy and mark you answer:

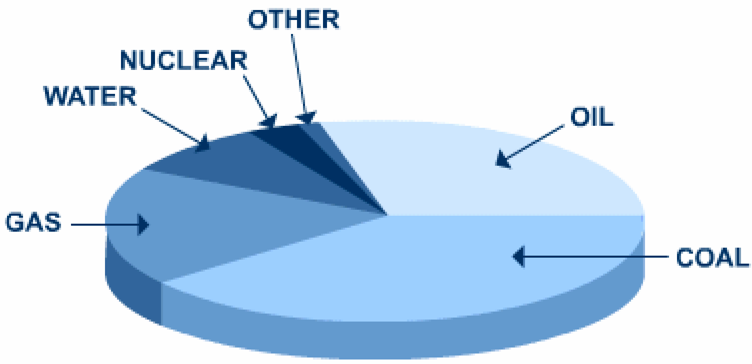


Fossil fuels

Fossil fuels

The fossil fuels are oil, gas and coal. They are **non-renewable** energy sources, which means when the existing supplies run out, they can't be replaced! We are very reliant on fossil fuels in the modern world.

Do you remember all the aggro during the fuel crisis of September 2000 when there was a sudden shortage of petrol and diesel (both made from oil)?



These fuels have many uses, but the main ones are for heating, transport and generating electricity. The USA uses more fuel per person than any other country and much of the developed world uses plenty. As developing countries become more industrial, they use more and more energy.

Fossil fuels are formed under the ground. Dead matter is squashed under extremely high pressure over millions of years. This is why we can't remake it when it runs out.

Environmental impact of fossil fuels

When you burn any fossil fuel, gases escape into the air. The main two gases released are **carbon dioxide** and **sulphur dioxide.**

(**Note:** One reason why petrol tax is high in the UK is because the government was trying to discourage car use so that less pollution is released into the air.)

Carbon dioxide is the most common of several gases that contribute to the greenhouse effect. I think the effect is best experienced under a duvet! The heat that exists underneath can't easily get out, so you get hotter and hotter. For the Earth, the result is global warming. Sadly, it means more heat energy in the atmosphere, so the weather is more extreme (not just hotter). Worse still, is that the ice-caps melt raising the sea levels. Literally millions would be affected in countries like Bangladesh, even parts of England could go under the water.

Sulphur dioxide causes acid rain. The gas dissolves in rainwater to form an acid. The acid rain harms plants, animals and stonework. It is an international problem because acid rain clouds created in one country can be blown over to another country.

Nuclear power

When your parents went to school, nuclear power stations were the great hope to solve all the world's energy problems. 1 kg of Uranium can produce the same amount of energy as 10,000 kg of coal. Since then, the negative side to nuclear power has changed many people's view. Accidents at power stations like Chernobyl showed us that although nuclear power has many advantages over the fossil fuels, it is also highly dangerous.

Uranium is the fuel used in many nuclear power stations. Uranium is not burnt like coal or gas. Instead nuclear fission takes place. Atoms of uranium are split up which releases large amounts of energy. Left uncontrolled this could cause an explosion as in nuclear weapons, but when controlled the energy can be used to heat water to produce steam, just like in other power stations.

Unfortunately, nuclear fission produces harmful radiation. Radioactive substances are produced that release alpha, beta and gamma radiation into the surroundings. This can be harmful to plant and animal life.

Accidents are rare, but can be serious. After the Chernobyl accident in the Ukraine, radioactive particles were carried in clouds across Europe contaminating land hundreds of miles away from the accident. 15 years later, there is still an area around the power station that people are not allowed into.

The waste from the reactors is also radioactive. It can be stored safely, but it stays radioactive for years. Unfortunately this waste has to be stored somewhere but nobody wants the nuclear waste buried near their town!

So where are we going to keep putting it?

Alternative Energy Sources

Below is some general information about alternative energy sources, but there is a lot more on the web. Try the Centre for Alternative Technology or The Guardian Renewables page as a starting point if you are researching this area. For the exam, make sure that you know the advantages and disadvantages of each energy source.

Most of the alternative energy sources are renewable. This means there is either an endless supply of them so that they will not run out, or they can be easily replaced.

The power of water

Nothing new here! Water wheels were used at the start of the industrial revolution. Now we can use water running down a hill or falling over a dam to turn a turbine. This is called **hydro-electric power (HEP).**

Some developing countries get all their energy from hydro-electricity schemes on large dams. The Aswan dam was the first and most famous, in Egypt on the Nile. The down side is that the large lakes made behind a dam can drastically change the countryside, sometimes covering small villages.

Big waves at sea also have a lot of energy - too much energy really, as no large-scale scheme has been designed to cope with it! Also, the tide has a lot of energy. If you block in the water at high tide and then let it out through a turbine as the tide falls, you can generate electricity. But as with the dams, this alters the natural water levels, so the local habitat is affected.

Harnessing the weather

Solar power - The energy from the sun can be changed into electrical energy using solar panels. This is used in the UK even though it's not always sunny! Solar panels are often used alongside other energy sources, as it is not powerful enough to be used as the only source. Although the sun's energy is free the actual solar panels are very expensive to make which makes solar energy quite an expensive option.

This year, a company has started marketing roof tiles that are also solar cells, which can supplement your domestic electricity.

Wind power - Britain is a windy country! A lot of farmers make money by renting out land to build wind farms. This is a group of wind turbines that generate electricity from wind as slow as 5 miles per hour. It may only be a few years before over 10% of our electricity is wind generated. Look out too for the first wind turbines in back gardens. Unfortunately, some people don't like wind farms because they spoil the view or make a noise.

Wind power is a modern form of electricity production.

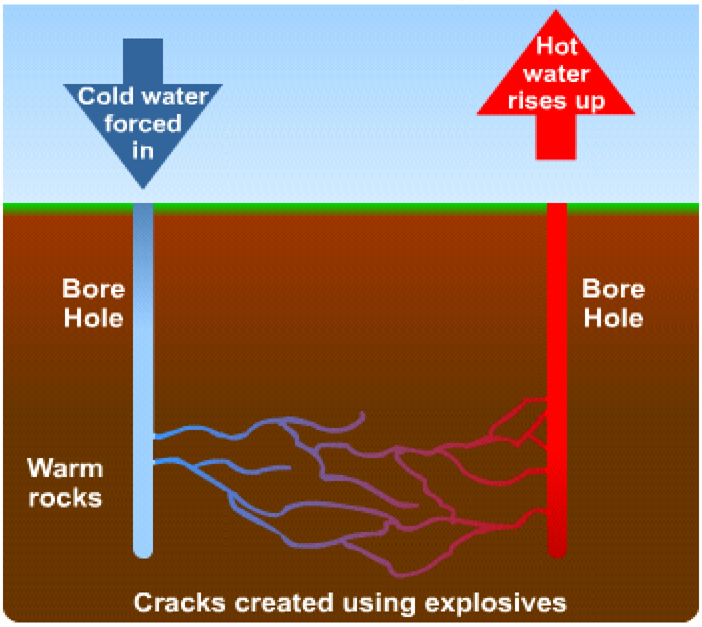
Other alternatives

Geothermal power uses the natural heat in volcanic rock under the ground to generate electricity. This is popular in Iceland but not likely to happen in

Biomass - when dead plants and animals rot the bacteria involved produce methane gas. This gas can be collected and burnt as a fuel. It is often called biogas. Although this makes good use of natural waste, unfortunately burning methane produces pollution like the fossil fuels.

Burning waste - Burning rubbish is not a way to avoid pollution, but it does preserve fossil fuels as well as avoid rubbish having to be put in landfill sites.

Crops for fuel - This is particularly popular in third world countries, as it is cheaper than buying fossil fuels. In Brazil, they grow a lot of Sugar Beet. It is processed into alcohol and used instead of petrol in cars.

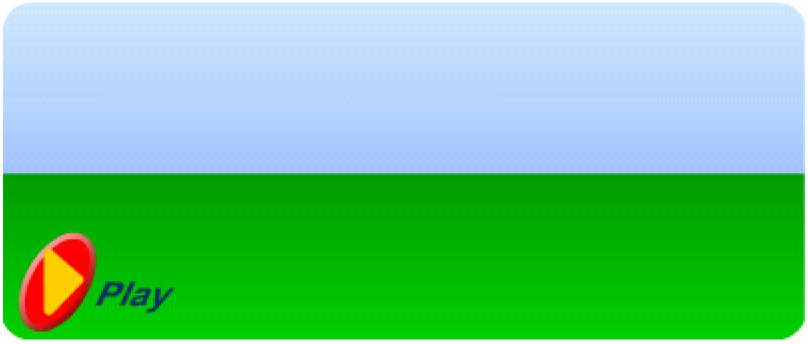


Work And Energy

Why do we have to do work?

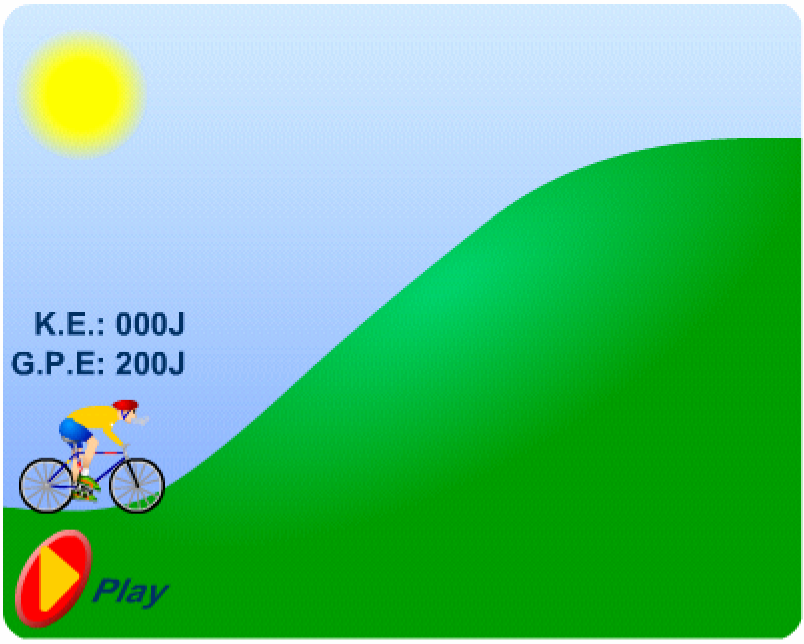
Work is done whenever energy is changed from one form into another.

If a football is kicked along the ground it has friction and air resistance trying to slow it down. The ball loses its kinetic energy as it slows down because it has to work against these forces. The kinetic energy is changed into heat energy.



If a cyclist travels up a hill, without pedalling, the kinetic energy the cyclist had at the bottom of the hill is changed into gravitational potential energy as he travels up the hill. The cyclist slows down as he loses kinetic energy.

The cyclist is doing work against the gravitational pull of the Earth trying to stop him going up hill.



Calculating work done

The amount of energy that has changed form is called the work done.

A crane lifts up a car. The higher it lifts the car the more work it will do. The heavier the car is the more work the crane will do.

So:

The bigger the force the greater the work done.

The further the distance the greater the work done.

The amount of energy or work done can be found using:

work done (or energy) = force x distance travelled

Work done (or energy) is measured in joules, **J**.

Force is measured in newtons, **N**.

Distance is measured in metres, **m**. (Not cm!!)

Note: The force must be in the same direction as the distance travelled.

Example 1:

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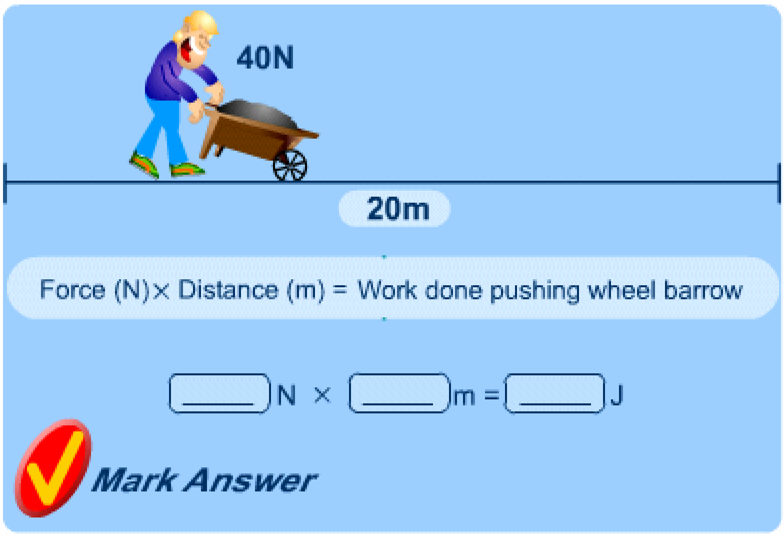
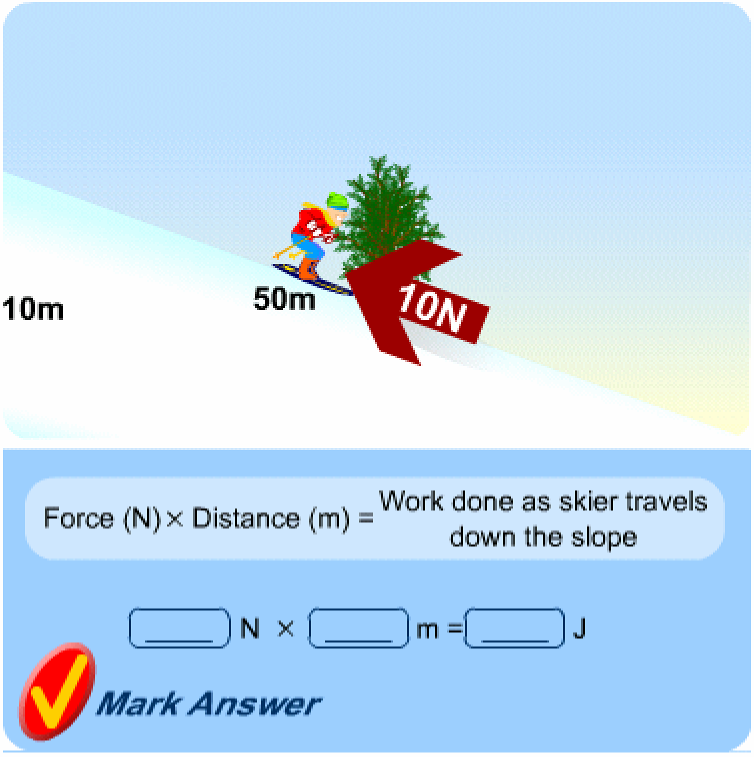


Example 2:



Note: In example 2 many students would make the mistake of using the wrong distance. Remember the distance must be in the same direction as the force.

Kinetic Energy

Kinetic energy tells us how much movement energy something has.

Kinetic energy doesn't just depend on how fast something is moving it also depends on mass.

If a car and a lorry are both travelling at the same speed the lorry will do much more damage if it hits something, than if the car does. The lorry has more kinetic energy even though they are both travelling at the same speed.

Calculating kinetic energy – higher level only

The amount of kinetic energy something has can be found using:

kinetic energy = ½ x mass x velocity^2

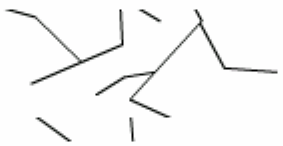
Kinetic energy is measured in joules, **J**.

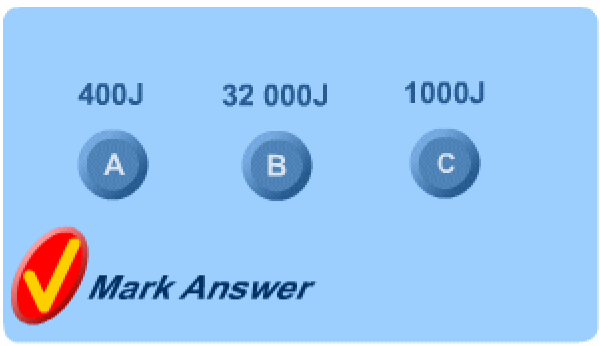
Mass is measured in kilograms, **kg**.

Velocity is measured in metres per second, **m/s**.

Here's one to try!

A pig of mass 80 kg flies over the S-Cool offices at 5 m/s. Choose the correct value for its kinetic energy from the options below:

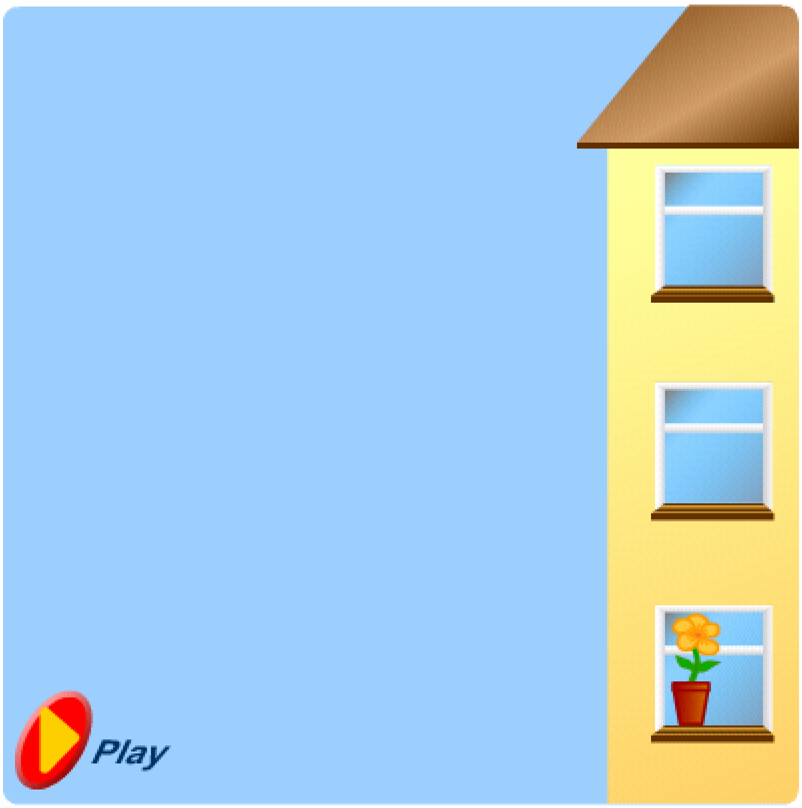




Gravitational Potential Energy

Gravitational potential energy (GPE) is a type of stored energy.

If flower pots fall out of a tall building, one from the ground floor window and one from the fourth floor window. **Which plant would be more likely to survive after it has hit the ground?**



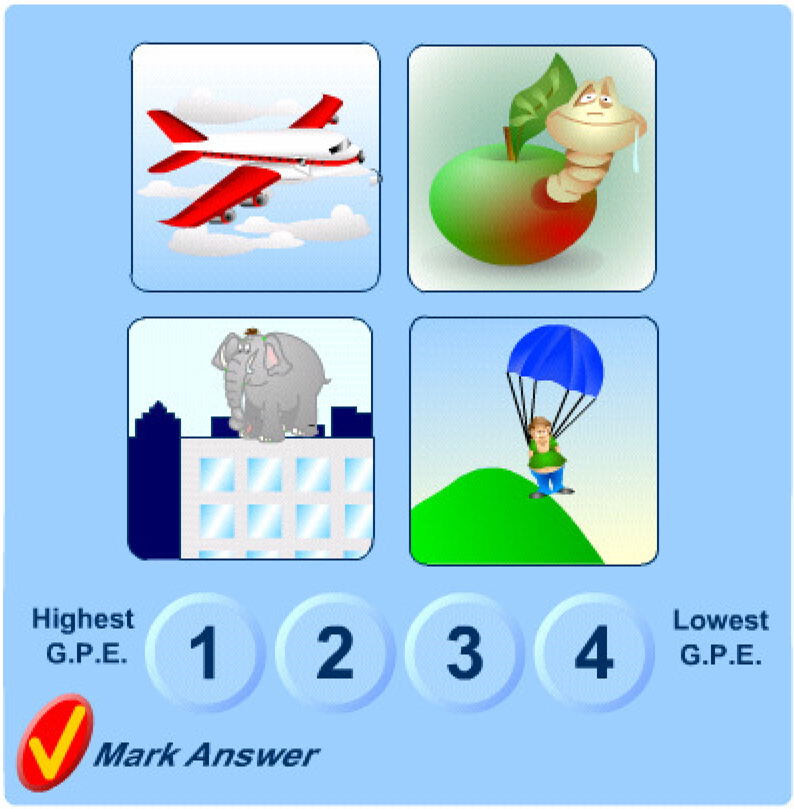
The higher up an object is the greater its gravitational potential energy. The larger the distance something falls through the greater the amount of GPE the object loses as it falls. As most of this GPE gets changed into kinetic energy, the higher up the object starts from the faster it will be falling when it hits the ground.

So a change in gravitational potential energy depends on the height an object moves through.

Lifting an apple up 1 metre is easier work than lifting an apple tree the same height. This is because a tree has more mass, so it needs to be given more gravitational **potential energy** to reach the same height.

So a change in gravitational potential energy also depends on the mass of the object that is changing height.

Put the following pictures in order, starting with the object that you think will have the most GPE.



Calculating gravitational potential energy – higher level only

The amount of gravitational potential energy can be found using:

Change in G.P.E.= mass x gravity x change in height

Gravitational potential energy is measured in joules, **J**.

Gravity is measured in newtons per kilogram, **N/kg** (or metres per second squared m/s^2)

Height is measured in metres, **m**. (Not cm!!)

Note: The formula above is the same as:

Work done (or energy) = Force x distance

Where force is the weight of the object changing height. Weight is calculated using:

weight = mass x gravity

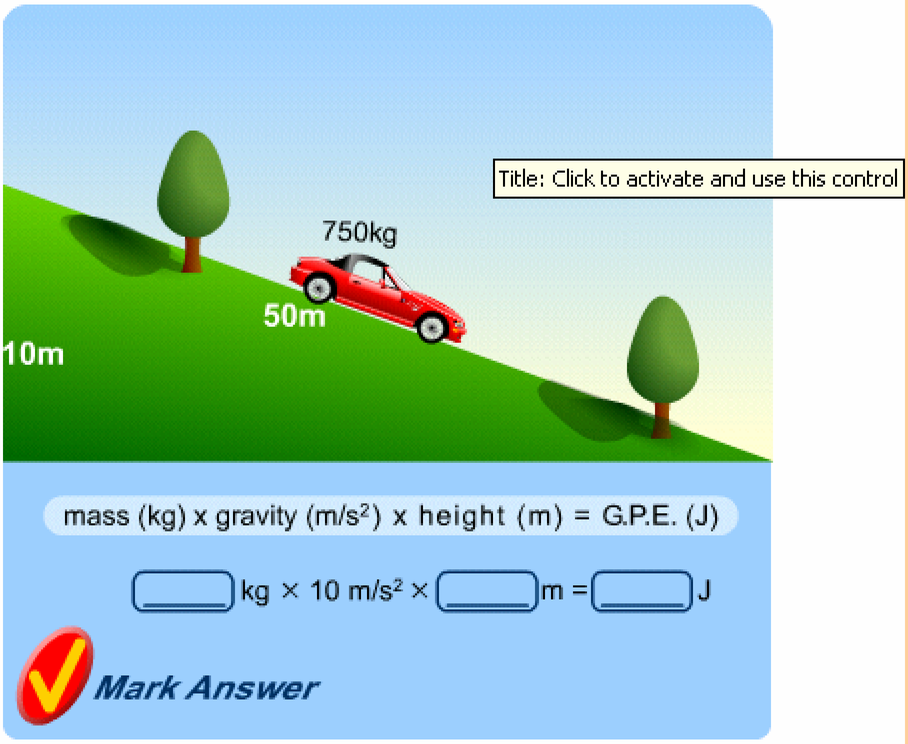
And the distance is the change in height.

Here's one to try!

In the example below, a car rolls down a frictionless slope.

How much gravitational potential energy does it lose by the time it reaches the bottom?

Enter the correct values in the boxes below:



If your answer was incorrect, did you remember to use the right distance. Remember the force and distance must be in the same direction. Weight is downwards, so you must use the distance downwards, not the distance along the slope!