

# CREATING

# SPARKS FOR ENERGY



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# CREATING SPARKS FOR ENERGY



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# CREATING SPARKS FOR ENERGY



## CHALLENGE BRIEF

### YOUR CHALLENGE

Imagine that a new state-of-the-art, eco-friendly house has just been built in your local area. The house has been described as the best of its kind. Not only were all the building materials recycled or sustainable, the house is also designed to be powered by renewable energy sources only.

The council are so impressed with this achievement in design and engineering, that they want to invite all local residents to the unveiling of the building and to watch the lighting of the bio-fuel power generator.

Such an occasion requires a suitably spectacular method of lighting ...

Your challenge is to design a human-powered invention for creating the spark that will light the generator.

You need to produce a presentation of your design with evidence that your device will work. The evidence could include working models of the device, diagrams, calculations and results from experiments. See the Things to consider section that follows, and the Presentation advice, for some help and guidance.

### THINGS TO CONSIDER

- ✿ You will need to work in teams of four to six people.
- ✿ Think carefully about the task ahead and manage your time and workload effectively.
- ✿ The device should require a considerable amount of human effort to create the spark. How will the human energy be provided? Consider if one person or several people will provide the energy?
- ✿ How will you convert the human energy into a spark? The *Starter Activity* will introduce you to different ways of starting a fire. The *Fire Factsheet* gives more information about fire.
- ✿ Fire can be dangerous. You will need to consider how to keep the people lighting the flame and the spectators safe. This may affect the materials you choose, and where the sparks will be generated. If you intend to create an electrical spark you will also need to consider electrical safety.
- ✿ You may need to change the speed, direction and force provided by the humans powering the device. The *Mechanics Factsheet* gives an introduction to some of the mechanisms you might use to do this.
- ✿ How can you make the lighting of the generator exciting to watch?
- ✿ In keeping with the new eco-house, it is important to consider sustainability during the Challenge. Where do materials come from? Would it be possible to use some recycled components?

However impressive your design, it won't be any use if it doesn't work! You need to demonstrate that your design will be reliable. Although you don't need to build your invention, you need to show evidence that it will work, for example by providing diagrams and calculations, building a model of some, or all, of your device, and giving results of the experiments you have carried out to test your design.

The Factsheets provide information that could help you with the Challenge. You may want to carry out further research yourself. Some suggestions for websites that you may find useful are provided on various Factsheets.

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## CHALLENGE BRIEF

### PRESENTATION ADVICE

Teams must show, clearly, how they arrived at their final choices. All proposals and recommendations must be justified - these justifications should form the main part of the presentation.

Communicating and, where possible, modelling ideas in a range of ways, is important to achieve this.

### SOME HINTS AND TIPS

Before starting the challenge, think about how to record and log experimental work as it is carried out.

- ✿ Think about how to present useful information – remember the process is just as important as the final proposal.
- ✿ Use a mixture of verbal, written and visual communication.
- ✿ Present scientific and technological information, rather than emotive arguments.
- ✿ Use scientific and technological language and terminology correctly.
- ✿ Be able to talk knowledgeably about every aspect of your challenge.
- ✿ Be prepared to answer any questions the judges might have about your design.

### Consider

- ✿ Video recordings.
- ✿ Photographs.
- ✿ Other forms of ICT.
- ✿ Diagrams and sketches – originals as well as ‘worked up’ final copies.

Your designs must be clearly labelled and annotated.

- ✿ Charts and graphs – if you need to present findings from any testing you may have carried out.
- ✿ Posters, leaflets, handouts.
- ✿ Making a prototype.

You may wish to attempt to make a prototype of your invention. It does not have to be ready for use, or even made from the correct materials – it can just be another way to illustrate your design.

Rather than making the whole device, you may attempt to model specific aspects of your design.

- ✿ Live demonstrations.

Rather than just using secondary research findings to justify your design choices, can you show how certain features work?

**Remember:** It is important, wherever possible, to test your ideas during the design process. The results can then inform your final decisions.

These are just some things to think about – you may think of more!

# CREATING SPARKS FOR ENERGY



## CHALLENGE BRIEF

### HEALTH AND SAFETY

STEMNET and those carrying out work on behalf of STEMNET cannot be held responsible for any accidents or injuries that occur as a result of this challenge. It is the responsibility of the teacher to ensure a full risk assessment is carried out before starting any practical work and that the correct health and safety measures are in place.

Always draw up plans before you start experimenting. The plans should include a **risk assessment**. This means you list the hazards (anything that could cause harm, e.g. some chemicals, heavy objects, fire). Then make a judgement about the risk from each (how likely is it to go wrong; how serious would it be if it did go wrong; how many people could be injured; would disabled people be at greater risk?). Finally decide what safety precautions (control measures) you need to adopt to reduce the risk of serious harm to an acceptable level. Make sure you discuss the plans with your teacher before starting any practical work.

### WORKING WITH FIRE

The following will give you some ideas about the risk assessment when experimenting with fire.

- ✿ Make sure you know the location of fire extinguishers and fire exits in the room.
- ✿ Make sure there is nothing flammable near the experiment.
- ✿ Check that there are no smoke sensors in the room (heat sensors will probably not be affected).
- ✿ Work on a heat resistant surface.
- ✿ Do not attempt to burn materials which might give off toxic fumes, for example plastics.
- ✿ Work in a well ventilated environment.
- ✿ Be aware of anyone with breathing difficulties.
- ✿ Make sure any long hair is tied back and loose clothing secured.
- ✿ Wear eye protection.
- ✿ Make sure that all fires are completely extinguished at the end of your experiment.
- ✿ Be careful not to dispose of smouldering material or something which might ignite spontaneously into waste bins.
- ✿ Handle any equipment which may become hot with tongs, or allow it to cool before touching.
- ✿ For burns, quickly cool the affected area under running water until first aid help arrives.
- ✿ For hair set alight, smother with a fire blanket, cloth or similar.
- ✿ For clothing set alight, remember stop, drop and roll (i.e. stop moving around, drop to the floor and roll so as to smother flames or, with flames on top, cover with fire blanket, coat or similar).

### IN YOUR DESIGN

- ✿ Make sure that the spectators and any people operating your invention are protected from any sparks.
- ✿ Any materials that will be near a heat source should be heat-resistant and non-flammable.
- ✿ Be aware of any areas that might get hot, and make sure that no one will come into contact with them.
- ✿ Make sure you consider other hazards as well as fire, for example chemicals if used, moving parts (which might trap fingers), heavy objects (which might topple over or drop on toes).

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} FIRE

### WHAT IS FIRE?

Fire is a rapid chemical reaction between oxygen and fuel which releases heat and light.

Heat is needed to start the reaction. After the fire is started, the reaction generates enough heat to keep itself going.

### THE FIRE TRIANGLE

The fire triangle shows the three components needed for fire. When one of these is taken away, the fire will go out. For example:

- ✿ A wood fire will go out when all the wood (the fuel) has been burnt.
- ✿ A fire blanket works by reducing the supply of oxygen to a fire.
- ✿ Cooling a fire with enough water will make it go out.

The most common way to put out a fire is to use water. This works by having a cooling effect – the heat turns the water into steam instead of keeping the fire going. The steam also reduces the supply of oxygen. However with some fires, adding water will make things worse, for example, with an electrical fire, water will conduct the electricity, increasing the danger. With a chip pan fire, the burning oil and the water will not mix, and adding water is dangerous. The water sinks below the oil, and then rapidly heats up, vaporises and expands, causing a fireball of burning oil to explode out of the pan.



### FUELS

Something which is easy to set on fire is described as highly flammable.

Different fuels start burning at different temperatures and will give off different amounts of heat. The surface area of the fuel will also make a difference to how easily it burns. The larger the ratio of surface area to volume, the more oxygen the fuel is exposed to, and the more easily and quickly it will burn. This is why small twigs burn more easily than thick logs. Powders have a very high surface area and if suspended in the air and ignited can even explode.

If a flammable gas mixes easily with air, it should burn readily.

### LIGHTING FIRES

To light a fire you have to get the fuel to a high enough temperature to ignite. But you only need to light a small volume of fuel to start a much bigger fire. A small spark is often all you need. When a fuel burns, the temperature of its flame is higher than the temperature that was needed to light the fuel. This can light fuels/materials which need a higher temperature to ignite. This is why fire can spread so easily. Although problematic in accidental fires, this principle is used in fire lighting methods.

For example, when building a log fire, usually some material which lights easily (tinder) is lit first. Some examples of tinder are birch bark, grass and paper. This is used to light small sticks, and finally these can set larger logs alight.

**Matches** also use this principle. The head of a match consists of chemicals which ignite at a fairly low temperature. When the match head is struck against sandpaper, the resulting friction heats it enough to ignite. The match head will then burn at a high enough temperature to set the wooden matchstick on fire.

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} FIRE

### BURNING METAL

Sparks made with a flint and steel can be used to light a fire. The flint is very hard (other hard materials can also be used) and cuts tiny pieces from the steel. As these tiny pieces are chipped off they are also heated by the friction between the flint and the steel. If the steel is hot enough, it will catch alight, and these tiny pieces of burning metal can be used to start a fire. You can also see steel burning if you set some steel wool on fire. Steel wool will catch fire more easily than a solid lump of steel because it has a higher surface area compared to its volume.

An easier way to create sparks is to use a special material called ferrocium. Ferrocium is a combination of rare earth metals, which ignite at low temperatures (around 150 °C), and some other metals to make it harder and more easy to use. Because ferrocium ignites at a lower temperature than steel, less friction is needed to make a spark. Ferrocium is used in disposable cigarette lighters and you can also get rods of it. Confusingly, ferrocium is sometimes called flint. As with the flint and steel method, striking the ferrocium with steel will create sparks, but in this case it is the ferrocium burning rather than the steel. Ferrocium rods are sometimes called firesteels or fire sticks, and can be obtained from shops which sell outdoor and survival equipment.

### OTHER METHODS FOR LIGHTING FIRES

Friction is also used to light fires by **rubbing two sticks together**. This is an ancient way to start fires, and requires not only a great deal of effort, but also expertise.

Fortunately the heat from sun is usually not strong enough to start fires, however by using either a parabolic mirror or a **magnifying glass** to focus the sun's rays on to a flammable material a fire can be started.

When air is compressed quickly, it will heat up. This is another ancient method for starting fires. It can be demonstrated using a **fire piston**. Diesel engines use the same principle.

Electrical sparks can contain enough heat to ignite a fire, this is why it isn't a good idea to use an electrical switch when there has been a gas leak. Electricity can also be used to generate heat by passing current through a material with a high resistance, this is how **electric fires** and toasters work. If you've ever set your toast on fire, you'll know that it's possible to start a fire this way.

### USEFUL RESOURCES

There is a useful educational video of a fire-piston in action at:

<http://www.nationalstemcentre.org.uk/elibrary/resource/4101/fire-piston>



# CREATING SPARKS FOR ENERGY



## {FACTSHEET} ENERGY STORES AND ENERGY TRANSFERS

For the challenge you need to find a way to use energy stored in a human body to light a bio-fuel generator. It doesn't necessarily take a great deal of energy to create a spark, so you also might think about how any surplus energy might be used to make the lighting more exciting.

### ENERGY AND POWER

Energy is needed to make things happen. Remember, energy cannot be created nor destroyed. Power is the rate at which energy is transferred from one place to another.

Power = energy  $\div$  time, where energy is measured in joules (J) and power is measured in watts (W).

There is a limit to the power a human can generate, so you may need to find a way to store this energy and release it suddenly to create your spark.

### ENERGY STORES

Energy can be stored in many ways and released when needed, sometimes slowly and other times very quickly. Energy stores include:

**Chemical** – energy stored in chemical compounds and released when reactions happen, e.g. combustion (fuel and oxygen) and batteries.

**Kinetic** – the energy stored in a moving object given by the equation:  $KE = \frac{1}{2}mv^2$ , where KE = kinetic energy (joules), m = mass (kilograms) and v = velocity (in metres per second).

**Gravitational potential energy** – the energy stored in an object by its position. Kinetic energy used to lift an object is stored as gravitational potential energy. Dropping the object releases energy. The gravitational potential energy is given by the equation:  $PE = mgh$ , where PE = potential energy (joules), m = mass (kilograms), g = acceleration due to gravity (10 Newtons per kilogram) and h = height (metres).

**Elastic** – it takes energy to stretch an elastic band and to stretch or squash a spring. This energy is stored in the elastic band or spring until they are released.

**Thermal** – energy stored in hot objects.

**Magnetic** – it takes energy to pull attracting magnet apart or pushing repelling magnets together. This energy is stored in the pairs of magnets.

**Electrostatic** – it takes energy to pull attracting electric charges apart or pushing repelling electric charges together.

**Nuclear** – energy stored in atomic nuclei released through radioactive decay, fission or fusion.

**Mechanical** – flywheels are given energy and spin. When the input of energy stops, the flywheel continues to spin and be a store of energy.

### TRANSFERRING ENERGY

Energy can be transferred in various ways, including:

**Mechanically** – moving an object using forces and levers.

**Electrically** – an electric current is the movement of electrons through a conductor.

**Heating** – a hot object will warm a colder object (the hotter object cools). This can happen by conduction, convection or radiation.

**Radiation** – electromagnetic waves such as light, sound and microwaves transfer energy from place to place.



# CREATING SPARKS FOR ENERGY



## {FACTSHEET} ENERGY STORES AND ENERGY TRANSFERS

### ENERGY STORES AND TRANSFER

What matters is not the amount of energy stored, but the rate at which energy is transferred.

### EFFICIENCY

An electric light bulb produces light. In a filament light bulb, energy is transferred to the metal filament which gets very hot and glows. So some energy is 'useful' in that it produces light, but some is 'wasted' because it only causes the bulb to get hot. It is the same with all devices – not all of the energy put in produces useful energy, some is wasted.

The efficiency as a measure of a device can be calculated using the equation:

$$\text{Efficiency} = (\text{useful energy out}) \div (\text{energy in})$$

In a laptop, energy is input by an electric current. Some is used to produce light (so that you can see what is on the screen) and sound (so that you can listen, for example, to podcasts and videos). However, some is wasted because it simply makes the laptop hot.

### USEFUL RESOURCES

[www.energyeducation.tx.gov/energy/section\\_1/topics/what\\_is\\_energy/index.html](http://www.energyeducation.tx.gov/energy/section_1/topics/what_is_energy/index.html)

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} MECHANICAL DEVICES

You may want to store the energy from human power and release it in a concentrated burst. You may want to build a mechanical device and be able to change the direction and speed of the motion.

### MECHANICAL ADVANTAGE

Lifting a mass of 250 kg needs a force of nearly 2500 Newtons (for more about force see the Human Power Factsheet). Believe it or not, you can lift 250 kg, but you will probably need a bit of help. Simple machines such as levers and pulleys can take the force we put into them and output a higher force. Dividing the output force by the input force gives the mechanical advantage, so a mechanical advantage of 2 means that you get out twice the force that you put in. There is a catch. We can't get any more energy out of a machine than we put in. The work equation tells us:

$\text{work} = \text{force} \times \text{distance}$

So if we are getting twice the force out, the force will only be able to travel over half the distance. We can also make this trade-off in the opposite direction, if we want to make something quickly, we can use a machine that outputs less force over more distance.

### FRICTION

Friction is an important force to consider when designing machines.

Friction occurs when two surfaces are in contact. When they are not moving relative to each other, friction is preventing movement. For example, if you try to slide a heavy piece of furniture across the floor the friction will create a force in the opposite direction to the direction you are pushing. The force due to friction has an upper limit, so if you push hard enough against a piece of furniture it starts to slide across the floor.

This type of friction (called static friction) can be useful because it means that we can get a grip on objects. To increase static friction you can increase the force pushing the two surfaces together, or you can change the texture or composition of one or both of the surfaces. For example, someone trying to open a jam jar might grip the lid more tightly, and put a dishcloth over the lid to stop their hands slipping.

When two surfaces are moving relative to each other, friction creates a force in the opposite direction to the movements which slows it down. Kinetic energy is transferred and heats up the surroundings. This may be the way you want to generate the spark for this challenge, but it might also make your device less efficient. In mechanisms with moving parts, surfaces which are in contact with each other are generally smooth, and often lubricated with oil to reduce friction. In joints which move a lot, for example in the axles of wheels, ball bearings are often used. The balls in a ball bearing are free to move, so that rather than surfaces rubbing against each other, the balls turn.

# CREATING SPARKS FOR ENERGY

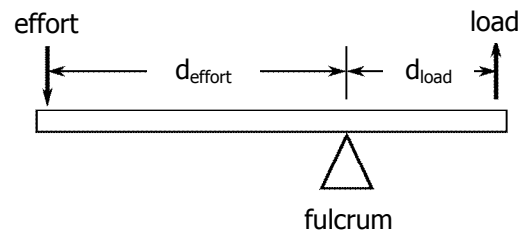


## {FACTSHEET} MECHANICAL DEVICES

### LEVERS

For a lever you need a rigid object and a fixed pivot point (the fulcrum). The lever shown has the input force and the output force on opposite sides of the fulcrum (known as a class 1 lever), but you can also get levers where the input and output forces are both on the same side of the fulcrum. The mechanical advantage is given by the equation:

$$\text{Mechanical advantage} = \text{load} \div \text{effort} = d_{\text{load}} \div d_{\text{effort}}$$



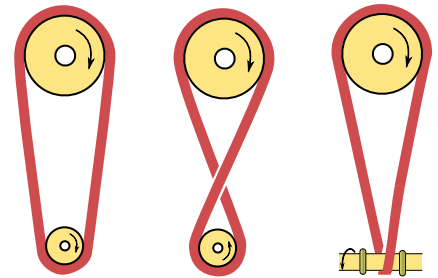
### PULLEYS

A pulley is a wheel (also sometimes called a drum) which usually has a groove round the edge to hold a rope.

Using a rope and a single fixed pulley can change the direction of a force, but pulleys really come into their own when you either allow the pulley to move, or combine more than one pulley. Pulleys can then give a mechanical advantage. This type of rope and pulley system is often called a block and tackle. They are used in cranes and sailing boats.

Pulleys can also be used in drive-belt systems. Two pulleys are connected by a loop (the drive-belt), often made of rubber. If the loop is pulled tight enough turning one of the pulley wheels will make the other turn as well. A mechanical advantage can be gained if the two wheels are different sizes.

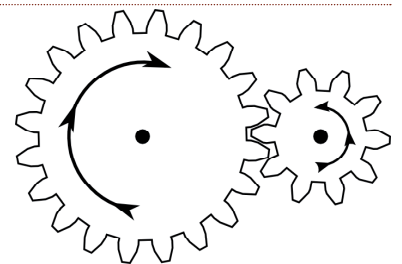
Pulleys depend on having a good grip between the pulley wheel and the rope or belt in contact with it. There is also the possibility that the rope or belt will stretch.



### GEARS

Gears work in a similar way to drive-belt systems, but instead of using friction, gear wheels have teeth which can mesh with the teeth belonging to other gear wheels. Turning one wheel will then cause the other wheel to turn as well. The meshing teeth prevent slipping which can give an advantage over a pulley system.

Gear wheels which are designed to work together will have teeth of the same size, so that gear wheels with a larger diameter will have more teeth. In the diagram, the large wheel on the left has 20 teeth and the small wheel on the right has 10 teeth. When both wheels have turned by 10 teeth, the small wheel will have made a full rotation, and the big wheel will only have made a half rotation. This means that the smaller wheel will spin at twice the speed of the larger wheel. Notice that the wheels spin in opposite directions. If you want to increase the speed of rotation (but end up with less force) you can drive a smaller wheel with a larger one. If you want more force and less speed, you can drive a larger wheel with the smaller one.



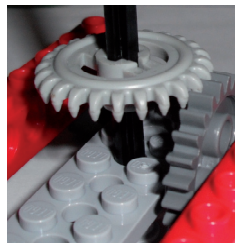
# CREATING SPARKS FOR ENERGY



## {FACTSHEET} MECHANICAL DEVICES

The *gear ratio* is the ratio in number of teeth between the gear wheel doing the driving and the gear wheel giving the output. You can combine several gear wheels to make a *gear train* with a higher *gear ratio*.

The two photos show other ways to use gears (built with *Lego™*). On the left are gears which mesh at right angles to each other. On the right is a *rack and pinion* system which can be used to translate rotational motion into linear motion.



<http://science.howstuffworks.com/transport/engines-equipment/gear.htm>

## HYDRAULICS AND PNEUMATICS

Hydraulic systems use liquids to move objects, pneumatic systems use gases. If you blow up a balloon (not too much) and squeeze one part of it, then the part you aren't squeezing will get bigger. You can do the same with a balloon filled with water. The advantage of using a liquid rather than a gas is that gases change volume under pressure and liquids don't, so a hydraulic system will be more responsive than a pneumatic one. As well as giving mechanical advantage, hydraulic and pneumatic systems are also very good for transferring force from one place to another.

## USEFUL RESOURCES

Construction toys such as *Lego™* and *Knex™* are good for experimenting with gears.

Levers and pulleys are examples of simple machines. For more about simple machines see

✿ <http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>

More detailed description of how pulleys work can be found here

✿ <http://science.howstuffworks.com/transport/engines-equipment/pulley.htm>

For more about hydraulics see

✿ <http://science.howstuffworks.com/transport/engines-equipment/hydraulic1.htm>

✿ [http://www.ehow.com/list\\_6639308\\_school-projects-hydraulics.html](http://www.ehow.com/list_6639308_school-projects-hydraulics.html)

For some inspiration see

✿ <http://www.nucleuslearning.com/content/hydraulics-and-pneumatics-projects>

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} ELECTRICITY

### ELECTRICAL CHARGES

Have you ever rubbed a balloon against your jumper then got it to stick to the wall? If so, you have experienced the build up of electrical charge. There are two types of electrical charge, positive and negative.

An atom consists of a nucleus with electrons moving around it. The nucleus contains protons and neutrons. Protons have a positive charge. Electrons have negative charge. An atom has the same number of protons and electrons, so that charges cancel each other out. Some atoms transfer one or more of their electrons to other atoms. Those that transfer the electrons now have a positive charge and are called cations. Those that gain electrons have a negative charge and the particles are called anions. Cation and anions are called ions.

Some materials give up electrons very easily, others pick up electrons more easily. For example, if you stroke a balloon several times on your hair, the hair gives up electrons and the balloon captures them. Your hair becomes positively charged and the balloon becomes negatively charged. Opposite charges attract one another. Charges of the same type are repelled. Since your hair and the balloon have opposite charges, your hair will stick to the balloon when you try to take it away. When you take the balloon away completely, your hair may still stick out because they have the same charge and repel one another. If you bring the balloon close to the hair again, the hair will move towards it. A supermarket carrier bag, a plastic ruler or even a fleece should all have the same effect, however, stroking the hair with your hand, or a piece of woollen or nylon clothing will leave the hair flat. This is because skin, wool and nylon do not capture electrons easily.

### CURRENT

Current is the flow of electric charge. For a current to flow, the electric charges in a material need to be able to move. Conductivity is a measure of a material's ability to carry electrical current. Electrons are free to move in metals, which makes them very good conductors. In water there are usually some ions which are free to move. This means that although water is not a good conductor, it can conduct enough current to make it dangerous to mix electricity and water. Salt water has more ions in it, and therefore is a better conductor of electricity.

Materials which don't conduct current are called insulators. The coverings on electrical wires in the home need to be very good insulators to prevent us getting electrocuted. Air is usually a good insulator, but under some conditions it can break down and become a conductor, and this is when we get sparks.

For a current to flow you also need a *potential difference* (sometimes called *voltage*) to get the charges moving. A potential difference is always measured between two points. For example, a battery's potential difference is measured across its two terminals. Often the potential difference is given relative to a reference point called the earth or ground. As the name suggests, the earth is usually connected to real earth, for example using a metal rod with one end in the ground.

It is not high voltages which are usually dangerous, but the currents they can cause, which can cause burns and interfere with the electrical signals your body uses to work properly. If you touch a conductor which was at a high voltage relative to earth, you would be fine as long as you were not touching anything at a different voltage. If you were to come into contact with a connection to earth, there would be a big voltage across your body, and this would result in a current flowing through your body.

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} ELECTRICITY

### GENERATING ELECTRICITY

Devices like the Van de Graaff generator use a similar principle to rubbing a balloon on a jumper. The surface of a moving rubber belt collects charge, which is then transferred to a metal sphere. Although this is a good method for creating sparks and making people's hair stand on end, it isn't so good for providing electricity for people's homes.

Certain materials acquire electric charge when stress is applied to them. This is the piezoelectric effect. The piezoelectric effect is used to create sparks in gas lighters, and also in some microphones and speakers.

The main method for converting movement into electrical energy is to use the fact that a changing magnetic field will induce a voltage in a loop of wire. So if you move a magnet near a wire, a voltage will be induced in it. To increase the voltage you can increase the number of loops of wire, making a coil.

The same principle is used in generating most of the electricity used in the UK.

### STORING ELECTRICITY

The most common way to store electricity is by using batteries. Batteries store chemical energy. With rechargeable batteries the chemical reactions are reversible by inputting energy when the battery's store is used up.

Another way to store electrical energy is to use a capacitor. A capacitor consists of two electrical conductors (often called plates) with an insulator between them. A Van de Graaff generator acts as a capacitor, with the metal dome as one plate, and the ground as the other plate. The amount of energy a Van de Graaff generator can store depends on the diameter of the dome. For safety it is recommended that the dome should not be more than 25 cm in diameter. Also, the dome should not be connected to any other capacitors because dangerous levels of energy might be accumulated. Van de Graaff generators with large domes have been used as sources of very large voltages.

### RESISTANCE

When current passes through most materials, some energy is transferred to the surroundings and warms them. How much depends on the material's resistance. Materials with high conductivity have low resistance. The resistance of a wire depends on what it is made of, its length and its thickness. Steel wool can be set on fire with a battery because it is made of very thin wires with a high resistance.

The heating effect of a current can cause problems, for example, heating up TVs and computers wastes energy. But it can also be useful, for example, in toasters, kettles and electric ovens. All these appliances contain heating elements which are made of materials with a high resistance that will not burn or melt at the high temperatures required. Fuses in plugs contain a thin wire which will heat up and melt if the current passing through it is above the rating of the fuse. This breaks the circuit, so the current cannot reach the appliance attached to the plug and damage it.



# CREATING SPARKS FOR ENERGY



## {FACTSHEET} ELECTRICITY

### ELECTRICAL SPARKS

Air is an insulator, but there is always a few ions and free electrons in it. The presence of a high voltage will make these charged particles move faster and faster. If they are moving fast enough there may be collisions between the charged particles and gas molecules, breaking the molecules up to create more free electrons and ions. In this way the number of charged particles can multiply very quickly. Also, when the charged particles hit a conductor this will also release even more charged particles. If the conditions are right there can be an avalanche effect with more and more charged particles being created until there are enough of them to allow a considerable current. This is when you get a spark.

### ELECTRICAL SAFETY

Don't experiment with mains electricity. It can kill. In this challenge remember the only power source should be human.

The sorts of shocks you get from a Van de Graaff generator should not present any risks to students unless they have any of the following unusual medical conditions: coronary heart disease (e.g. angina, history of heart attack); cardiac rhythm disorders; intra-cardiac conduction pathway anomalies; presence of an implanted cardiac pacemaker; hypertension (high blood pressure).

When working with electricity: remove any metal jewellery, such as rings and bracelets; remember that electricity and water are never a good mix; avoid touching any bare wires.

The dome of a Van de Graaff generator should not be more than 25 cm in diameter and should not be connected to any other capacitors because dangerous levels of energy might be accumulated. Van de Graaff generators with large domes have been used as sources of very large voltages.

### USEFUL RESOURCES

✿ <http://faraday.theiet.org/posters-print/posters/index.cfm>

✿ [www.physics4kids.com/files/elec\\_intro.html](http://www.physics4kids.com/files/elec_intro.html)

For more about Van de Graaff generators see

✿ <http://science.howstuffworks.com/transport/engines-equipment/vdg.htm>

An example of a very simple electric generator you can build is given here

✿ <http://www.creative-science.org.uk/gensimple1.html>

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} HUMAN POWER

In this challenge, you are creating a human-powered fire lighter. To do this the person (or people) must provide a force (a push or a pull) to something. But how much force needs to be applied, where, and in what direction should it be applied, and for how long?

### FORCES

A force can change the speed an object is moving at, its direction, or its shape. Force has magnitude and direction, for example a force upwards is clearly not the same as a force downwards. Force is measured in newtons (N).

Force is given by the equation:  $\text{force} = \text{mass} \times \text{acceleration}$

The mass of an object is the amount of matter it contains, and is measured in kilograms (kg). Be careful when talking about mass and weight. In physics, the weight of an object is the force that gravity is applying to that object and is measured in newtons. On the moon, the weight of an object would be lower because the gravity is lower, but the mass would be the same. When buying groceries or baking, it's fine to talk about something's weight being measured in kg, but never do this in a science context. The equation tells us that the heavier an object is, the more difficult it is to change its speed, for example it is much easier to push a toy car than a real one.

Often, when people talk about acceleration they mean an increase in speed, but in physics, acceleration can also mean a decrease in speed or a change in direction. So you need to apply a force to slow a moving object down or to change its direction. For an object travelling in a straight line, you can work out its acceleration using the equation:

$\text{Acceleration} = (\text{final speed} - \text{initial speed}) \div \text{time}$

speed is measured in metres per second ( $\text{m/s}^1$ ).

acceleration is measured in metres per second per second ( $\text{m/s}^2$ ).

When considering how much force is needed to move an object, you also need to consider what other forces are acting on it. On Earth, the force of gravity pulls everything downwards. You can see this every time you drop an object. The gravity will make the object get faster, and faster, so that an object dropped from the top of a building will hit the ground faster than an object dropped from a ground floor window. Falling objects don't keep accelerating forever because they will reach a speed called the terminal velocity, where the downward force from gravity is balanced out by the upward force of air resistance.

The acceleration due to gravity ( $g$ ) is  $10 \text{ m/s}^2$ . This means that the force due to gravity is approximately ten times the mass of an object. So a 10 kg suitcase experiences a downward force of 100 N.

Air resistance is an example of friction which is another type of force. For more about friction see the mechanical devices factsheet.

You can also get forces due to magnetic field (e.g. a magnet sticking to a fridge) and electric fields (for more information see the electricity factsheet).

### MEASURING FORCES

To measure forces you can use a force meter. Most of the weighing scales that we use, for example, bathroom scales and kitchen scales are actually types of force meter. These measure the downward force due to gravity in Newtons and then convert this into kg.

# CREATING SPARKS FOR ENERGY



## {FACTSHEET} HUMAN POWER

### WORK AND POWER

The energy (measured in joules) used to move things is called work. It is given by the equation:

Work = force x distance

Using this we can work out that lifting a 10 kg suitcase (which needs 100 N of force) a metre from the ground needs 100 J of energy.

Power is the rate at which energy is used. It is calculated by dividing the energy used by the time taken to use it. Remember, energy cannot be created or destroyed, so when we talk about using energy, we are talking about transferring it from one place to another.

### EFFICIENCY

You might have noticed that although the work equation tells us that you don't need to do any work (use any energy) if you are holding a 10 kg suitcase and not moving, it certainly doesn't feel that way. This is because we are not working efficiently.

We use food to provide us with energy. This energy enables us to move, but most of it is used, for example, to keep our hearts beating, digest food and keep our bodies warm. If you compare the energy in the food we consume with the amount of physical work we do, we are not very efficient.

### THE HUMAN BODY

We can apply forces because we have a rigid skeleton, which supports the muscles which allow us to move. Our joints allow us a range of movement. Because of the way the body is constructed, some movements are easier to make than others. There is also a great deal of variation between different people.

Muscles are made up of bundles of fibres which can contract. You have muscles which automatically do the things that keep you alive, like making your heart beat and digesting your food, and muscles that you use to move around (skeletal muscle). There are two main types of muscle fibre, slow twitch and fast twitch. Fast twitch fibres can contract quickly and with more force than slow twitch fibres but quickly tire. Slow twitch fibres cannot contract so quickly, but they can keep going for longer before becoming tired. We all have a mixture of both these types of muscles, but in different proportions.

✦ [www.wanderworks.com/simple\\_muscle/muscle\\_groups.htm](http://www.wanderworks.com/simple_muscle/muscle_groups.htm)

✦ [www.bbc.co.uk/science/humanbody/body/factfiles/muscle\\_anatomy.shtml](http://www.bbc.co.uk/science/humanbody/body/factfiles/muscle_anatomy.shtml)

✦ [www.teachpe.com/gcse\\_anatomy/muscles.php](http://www.teachpe.com/gcse_anatomy/muscles.php)

### ACTIVITIES

Although your flame lighting device should require a decent amount of physical effort to work, you don't want to design something that no one is strong enough to power. You might do some experiments to determine the most effective way for your human power source to provide the energy for your flame-lighting method. Is it better to use short, high-power bursts of energy, or to require less power, but keep going for a longer time? The type of experiments you perform will depend on how you want to power your invention, for example, if you are using bicycle-style pedalling you might want to measure how fast your team members can pedal, and how long they can sustain a certain rate of pedalling. You might also want to consider how long the lighting should take. Ideally, it should take long enough to build some suspense, but not so long that the spectators get bored.

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} INTRODUCTION

The challenge is for 11-14 year olds to design a spectacular human-powered invention for creating the spark which lights the bio-fuel generator of a newly built state-of-the-art, eco-friendly house.

The students need to produce a design for their invention and enough evidence to convince the judges that the device will work. This could include working models of part, or the entire device, diagrams, calculations and results from experiments. The experiments should demonstrate that the device is reliable, for example by successfully repeating a test of the spark-generating method a number of times. The students should bear in mind that the lighting might take place in an outdoor setting, so the effects of wind and rain should be considered. The students do not have to design all the components of the invention themselves, for example a bicycle dynamo might be used to generate electricity. However, the device shouldn't use any power sources other than human effort.

The *Starter Activity* and the *Fire* Factsheet should give the students some ideas about how the spark might be created to light the generator. They can then consider how to provide the energy to achieve their chosen method. The *Energy Transfer* Factsheet gives methods for converting one type of energy to another. The *Electricity* Factsheet gives some information about using electricity but the students don't have to use electricity in their invention.

The design should make the lighting enjoyable for an audience. The students should also address the safety of the spectators and the person or people providing the energy.

Students should work in teams of four to six people. Teams will need to manage their time effectively, sharing out different tasks. They must make sure they meet the Challenge Brief but not take on more than can be realistically completed in the time available. Careful planning is required.

### STARTER ACTIVITY

The *Starter Activity* could be used to introduce the students to the Challenge. It is designed to introduce students to different methods for lighting fires and start them thinking about which methods would be suitable for lighting the bio-fuel generator. It should also get the students to think about fire safety.

### THE FACTSHEETS

The Factsheets provide information that may help the students when starting the Challenge. The information could be used to give the students an introduction to some of the concepts they might use in their design and to get students to start thinking about how they can demonstrate that their design will work. They also provide some links to other useful and interesting resources.

It is important to stress that the students should explore their own thoughts and ideas, and will need to carry out further research once they have started to design their flame-lighting method.

The Factsheets do not always need to be printed out. They are there as a reference for students. Where possible, encourage students to look at the resources online.

### PRESENTATION

The *Challenge Brief* provides guidance for students on what they need to do and how to present their work.

When developing their presentations, students should be reminded about features of good communication:

- ✿ Using a mixture of verbal, written and visual communication.
- ✿ Presenting mathematical and scientific information, rather than emotive arguments.
- ✿ Using mathematic and scientific language and terminology correctly.
- ✿ Being able to talk knowledgeably about every aspect of the Challenge.

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} INTRODUCTION

### HEALTH AND SAFETY

Although students are asked to make a risk assessment as part of their plans, teachers must check this before students start any practical work. In particular, teachers should check that what students propose doing is covered by the model risk assessments commonly used in schools and that they are adopting all relevant control measures (safety precautions). Alternatively, if the proposal is not covered by model risk assessments, teachers must follow their employer's procedure for obtaining a special risk assessment; usually this will involve contacting CLEAPSS on 01895 251496 (or e-mail [science@cleapss.org.uk](mailto:science@cleapss.org.uk)) or, in Scotland, contacting SSERC on 01383 626070 (or e-mail at [sts@sserc.org.uk](mailto:sts@sserc.org.uk)). Work will probably not be possible in laboratories fitted with smoke sensors, unless they can be switched off temporarily, because they may be triggered by the smoke generated. Heat sensors will probably not be affected because of the small scale of working, but it would be prudent not to experiment directly underneath a heat sensor.

Be vigilant in case plans get changed (without you being consulted!) as work progresses.

Note that if STEM Ambassadors are used they may, unknowingly, suggest procedures that are unsuitable for use in schools, or bring in equipment for which risk assessments are not available. If in doubt, contact CLEAPSS or SSERC.

The following commentary is based on the list in the Challenge Brief, which is intended to give students some ideas to think about when experimenting with fire but it is far from comprehensive because the project is so open-ended. There may well be some non-fire-related hazards, for example physical hazards if heavy equipment is used to generate electricity. Again, if in doubt, contact CLEAPSS or SSERC:

- ✿ Students must discuss their plans with the teacher before starting the experiment.
- ✿ Students should know the location of fire extinguishers and fire exits in the room but you would not normally expect them to know how to operate fire extinguishers. Wrongly used, they can do more harm than good.
- ✿ Make sure there is nothing flammable near the experiment – beware of decorations and posters.
- ✿ If fitted, make sure smoke sensors are switched off.
- ✿ Work on a heat resistant surface.
- ✿ Students must not burn materials which might give off toxic fumes, for example some plastics (if in doubt, do a small scale test in a fume cupboard).
- ✿ Work in a well ventilated environment.
- ✿ Be aware of anyone with breathing difficulties.
- ✿ Make sure any long hair is tied back and loose clothing is secured.
- ✿ Wear eye protection.
- ✿ Make sure that all fires are completely extinguished at the end of your experiment.
- ✿ Handle any equipment which may become hot with tongs, or allow to cool before touching.

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} INTRODUCTION

### EMERGENCY MEASURES

- ✿ For burns, quickly cool the affected area under running water until first aid help arrives.
- ✿ For hair set alight, smother with a cloth.
- ✿ For clothing set alight, remember stop, drop and roll (i.e. stop moving around, drop to the floor and roll so as to smother flames or, with flames on top, cover with a fire blanket, coat or similar).

In their designs students should:

- ✿ Make sure that the spectators and any people operating their invention are protected from any sparks.
- ✿ Any materials that will be near a heat source should be heat-resistant and non-flammable.
- ✿ Be aware of any areas that might get hot, and make sure that no one will come into contact with them.
- ✿ Make sure they consider other hazards as well as fire, for example chemicals if used, moving parts (which might trap fingers), heavy objects (which might topple over or drop on toes).



# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} CURRICULUM LINKS (ENGLAND)

### PROGRAMME OF STUDY FOR KEY STAGE 3

#### DESIGN AND TECHNOLOGY

##### KEY CONCEPTS

##### **Designing and making**

- Understanding that designing and making has aesthetic, environmental, technical, economic, ethical and social dimensions and impacts on the world.
- Applying knowledge of materials and production processes to design products and produce practical solutions that are relevant and fit for purpose.

##### **Creativity**

- Making links between principles of good design, existing solutions and technological knowledge to develop innovative products and processes.
- Exploring and experimenting with ideas, materials, technologies and techniques.

##### **Critical evaluation**

- Analysing existing products and solutions to inform designing and making.
- Evaluating the needs of users and the context in which products are used to inform designing and making.

##### KEY PROCESSES

- Generate, develop, model and communicate ideas in a range of ways, using appropriate strategies.
- Respond creatively to briefs, developing their own proposals and producing specifications for products.
- Apply their knowledge and understanding of a range of materials, ingredients and technologies to design and make their products.
- Solve technical problems.

##### RANGE AND CONTENT

- Understanding of users' needs and the problems arising from them.
- The criteria used to judge the quality of products, including fitness for purpose, the extent to which they meet a clear need and whether resources have been used appropriately.

- ✦ the impact of products beyond meeting their original purpose and how to assess products in terms of sustainability.
- ✦ aesthetic, technical, constructional and relevant wider issues that may influence designing, selection of materials, making and product development.

#### SCIENCE

##### KEY CONCEPTS

##### **Scientific thinking**

- Critically analysing and evaluating evidence from observations and experiments.

##### **Practical and enquiry skills**

- Assess risk and work safely in the laboratory, field and workplace.
- Plan and carry out practical and investigative activities, both individually and in groups.

##### **Critical understanding of evidence**

- Obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations.
- Evaluate scientific evidence and working methods.

##### **Communication**

Use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues.

##### RANGE AND CONTENT

##### **Energy, electricity and forces**

- Energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed.
- Forces are interactions between objects and can affect their shape and motion.
- Electric current in circuits can produce a variety of effects.

# CREATING SPARKS FOR ENERGY



{TEACHER NOTES} CURRICULUM LINKS (NORTHERN IRELAND)

## KEY STAGE 3 AREAS OF LEARNING

### TECHNOLOGY AND DESIGN

#### DEVELOPING PUPILS' KNOWLEDGE, UNDERSTANDING AND SKILLS

##### **Design**

identifying problems; investigating, generating, developing, modelling and evaluating design proposals; giving consideration to form, function and safety.

##### **Communication**

use of free-hand sketching and formal drawing techniques and ICT tools (including 3D modelling).

##### **Manufacturing**

selecting and using materials fit for purpose; safe use of a range of tools and processes; appropriate to materials, demonstrating accuracy and quality of outcome.

#### LEARNING OUTCOMES

- ✿ demonstrate practical skills in the safe use of a range of tools, machines and equipment;
- ✿ research and manage information effectively to investigate design issues, using Mathematics and ICT where appropriate;
- ✿ show deeper understanding by thinking critically and flexibly, solving problems and making informed decisions, using Mathematics and ICT where appropriate;
- ✿ demonstrate creativity and initiative when developing ideas and following them through;
- ✿ work effectively with others;
- ✿ demonstrate self management by working systematically, persisting with tasks, evaluating and improving own performance;
- ✿ communicate effectively in oral, visual (including graphic), written, mathematical and ICT formats showing clear awareness of audience and purpose.

### SCIENCE

#### DEVELOPING PUPILS' KNOWLEDGE, UNDERSTANDING AND SKILLS

##### **Forces and energy**

- ✿ forces and energy transfer
- ✿ using electricity

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} CURRICULUM LINKS (SCOTLAND)

### CURRICULUM FOR EXCELLENCE

#### TECHNOLOGIES

By applying my knowledge and skills of science and mathematics, I can engineer 3D objects which demonstrate strengthening, energy transfer and movement. **TCH 2-12a / TCH 3-12a**

#### SCIENCE

##### FORCES, ELECTRICITY AND WAVES

By contributing to investigations of energy loss due to friction, I can suggest ways of improving the efficiency of moving systems. **SCN 3-07a**

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} CURRICULUM LINKS (WALES)

### PROGRAMME OF STUDY FOR KEY STAGE 3

#### DESIGN AND TECHNOLOGY

##### SKILLS: DESIGNING

2. Identify and use appropriate sources of information to help generate and develop their ideas and products.
3. Be creative and innovative in their thinking when generating ideas for their products.
4. Identify and apply knowledge and understanding about technological, sustainability and health and safety issues to develop ideas for products that are achievable and practical.
5. Develop a specification for their product.
6. Explore, develop and communicate design ideas in a range of ways, including annotation, drawings and CAD.

#### SCIENCE

##### SKILLS: COMMUNICATION

Communicate logically by speech, writing, drawings, diagrams, charts, tables, bar charts, line graphs, videos and ICT packages using a wide range of scientific vocabulary, terms, symbols and conventions.

3. Work quantitatively, using appropriate mathematical conventions and using S.I. units appropriate to their work, e.g. kg, s, N, m, J, w.

##### SKILLS: ENQUIRY

Pupils should be given opportunities to carry out different types of enquiry, e.g. pattern-seeking, exploring, classifying and identifying, making things, fair testing, using and applying models, by:

##### Planning

Pupils decide on the most suitable type of enquiry to carry out and outline the planned approach/method, recognising, deciding upon and justifying each of the following when appropriate:

1. the choice of success criteria
2. predictions using previous knowledge,
3. understanding and preliminary work

##### Developing

Use a range of apparatus and equipment safely and with skill, taking action to control the risks to themselves and others.

2. Make sufficient relevant observations and accurate measurements, using ICT as appropriate, to a degree of precision appropriate to the enquiry.

##### RANGE: HOW THINGS WORK

1. the behaviour of current in electrical circuits
2. the conservation of energy and ways in which energy can be stored
3. how familiar devices/machines work by using electricity, light, sound and other energy transfers
4. the forces in devices and their relationship to work done and power

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} STARTER ACTIVITY

This activity should get the students thinking about the different ways a flame can be lit, and help them decide which method to use for their challenge invention.

### PREPARATION

You will need a range of equipment to demonstrate different methods of starting fires. Some methods are described in the activity section. It isn't necessary to use all the methods described here, but ideally there should be at least one method to demonstrate the use of

- ✿ friction
- ✿ chemical reactions
- ✿ an electric spark

If you are familiar with any other fire lighting methods, these can be used instead of, or as well as the methods described here.

To use some of the fire lighting methods described here, you may need some tinder i.e. a material which catches a spark easily. Birch bark or dry grass are often used as tinder. For the fire starting methods described here, you could use cotton wool as tinder.

### ACTIVITY

Ask for suggestions on how a flame can be lit. Introduce the fire triangle and fire safety (see the *Fire* factsheet.) The aim of the activity is to create fire using different methods.

### HEALTH AND SAFETY

Always consult your employer's risk assessment before starting experiments and consider whether it needs modification to suit the special circumstances of your school, room, equipment or students.

When experimenting with fire:

- ✿ Make sure you know the location of fire extinguishers and fire exits in the room.
- ✿ Make sure there is nothing flammable near the experiment.
- ✿ Work on a heat resistant surface.
- ✿ Do not attempt to burn materials which might give off toxic fumes, for example plastics.
- ✿ Work in a well ventilated environment.
- ✿ Be aware of anyone with breathing difficulties.
- ✿ Make sure any long hair is tied back and loose clothing secured.
- ✿ Wear eye protection
- ✿ Make sure that all fires are completely extinguished at the end of the experiment and that nothing smouldering or which might ignite spontaneously is discarded into waste bins.
- ✿ Handle any equipment which may become hot with tongs, or allow it to cool before touching.
- ✿ For burns, quickly cool the affected area under running water until first aid help arrives.
- ✿ For hair set alight, smother with a cloth.
- ✿ For clothing set alight, remember stop, drop and roll (i.e. stop moving around, drop to the floor and roll so as to smother flames or, with flames on top, cover with fire blanket, coat or similar).

# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} STARTER ACTIVITY

### FRICITION AND CHEMICAL ENERGY

#### MATCHES

- ✿ Get students to light a Bunsen burner with a match.
- ✿ Ask them to write down the mechanism by which the match ignited.
- ✿ Matches should always be struck away from the body.

#### FERROCERIUM AND STEEL - DISPOSABLE LIGHTER

- ✿ An empty disposable lighter can be used to demonstrate the sparks which usually ignite the fuel.
- ✿ The mechanism by which the fuel is released at the same time as the sparks are created can be discussed (this is also relevant for gas lighters which use piezoelectricity).
- ✿ Ask students to find out about the properties of ferrocium and why it is used in lighters.

#### FERROCERIUM AND STEEL - FERROCERIUM ROD

- ✿ Ferrocium rods (also known as fire steels) can be bought from outlets which sell outdoor and survival equipment.
- ✿ Either use some tinder, or gently scrape some of the ferrocium to make a heap of ferrocium powder on to a heat-resistant surface. Some ferrocium lighters come with a block of magnesium which creates a small pile of magnesium shavings on the tinder.
- ✿ Hold the ferrocium rod to the tinder and using either the steel provided with the rod, or another hard, sharp object, for example, a knife, quickly scrape downwards. Strike the ferrocium so that the sparks land on the pile of ferrocium powder or tinder.
- ✿ If you don't get sparks at first, try striking faster and with more force.
- ✿ To light a wooden splint, blow gently on the spark and add more tinder until there is enough of a flame.

### ELECTRIC SPARK

#### PIEZOELECTRIC LIGHTER

These are often found in the gas lighters used to light gas cookers and candles. A gas lighter which has run out of fuel could be used so that the students can see the spark created by the piezoelectric effect more easily. This could also be used to directly light a Bunsen burner but note that you need to have the air-hole partly open, unlike normal practice when lighting Bunsen burners. Older style piezoelectric gas lighters which don't use fuel can also be used in this way.

### GAS COMPRESSION

#### FIRE PISTON

- ✿ Fire pistons can be bought from education suppliers such as Cochranes of Oxford Ltd, or Timstar.  
[http://www.timstar.co.uk/Item/NA/HE43250/HYMAN\\_FIRE\\_PISTON.html](http://www.timstar.co.uk/Item/NA/HE43250/HYMAN_FIRE_PISTON.html)  
[http://www.cochranes.co.uk/show\\_product.asp?id=474&catid=217](http://www.cochranes.co.uk/show_product.asp?id=474&catid=217)



# CREATING SPARKS FOR ENERGY



## {TEACHER NOTES} STARTER ACTIVITY

It is also possible to build your own fire piston:

- ✿ a piece of tinder is placed in the bottom of the fire piston,
- ✿ the plunger is quickly pressed down, this compresses the air contained in the fire piston and causes its temperature to rise,
- ✿ the tinder should ignite,
- ✿ because of the small amount of oxygen contained in the fire piston, the plunger needs to be removed if the tinder is to be kept alight.

## OTHER POSSIBLE METHODS FOR LIGHTING FIRES

Sun and magnifying glass or concave mirror (focusing radiated heat).

Rubbing two sticks together (friction).

Chemical fire, for example by adding a few drops of glycerol to a few crystals of potassium permanganate [OXIDISING and HARMFUL], with a few drops of water added to accelerate the reaction. Note: this sometimes fails to ignite at once and has caused delayed action fires when carelessly discarded. If nothing happens after 10 minutes, wear heat resistant gloves and tip the mixture into a bowl of water.

Lighting a Bunsen burner using an electrical spark from a Van de Graaff generator.

## FIND OUT MORE

<http://www.tes.co.uk/teaching-resource/Banging-Chemistry-Fast-and-Furious-6038966/>

<http://chemistry.about.com/od/funfireprojects/a/make-chemical-fire.htm>

## DISCUSSION

Discuss how the different methods could be classified, what energy conversions are involved, how reliable the different methods are. Discuss what fire lighting methods might be most appropriate for lighting the bio-fuel generator, and how much energy needs to be provided.

# CREATING SPARKS FOR ENERGY



{ROLE MODELS} PHILLIPA CASSIE

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|  |  |

## 1. WHAT DO YOU DO?

I'm a Chartered Civil Engineer, currently working for E.ON as 'Foundation Package Manager' for the Humber Gateway Offshore Wind Farm.

## 2. DESCRIBE YOUR TYPICAL WORK DAY

I start by reviewing progress from the previous day, answer information requests and review any reports received. I will then spend a few hours 'on the shop floor' assessing the foundations that the wind turbines are on, known as a monopole foundation. Finally we review financial and contractual issues e.g. any claims or variations received from the contractor.

## 3. WHAT HOURS DO YOU WORK?

Approximately 45 hours a week 'flexi-time', when I'm on site the day can start at 5.30am and not finish until 7pm.

## 4. WHICH SUBJECTS DID YOU ENJOY MOST AT SCHOOL?

Maths and Science, particularly Chemistry. STEM subjects are key to become an engineer.

## 5. WHAT QUALIFICATIONS DO YOU HAVE?

I have an MEng in Civil Engineering and I'm a member of the Institution of Civil Engineers.

## 6. TO WHAT DEGREE WERE STEM SUBJECTS IMPORTANT IN GETTING YOUR JOB?

They were essential as my job requires practical application of fundamental scientific principles. You don't necessarily need to be brilliant at English but you do need to be a good communicator so you can discuss complex issues in a simple and practical way to enable everyone to understand what you are trying to achieve.

## 7. WHAT WERE THE MAIN FACTORS THAT ATTRACTED YOU TO YOUR CURRENT JOB?

Civil engineering is all about creating, improving and protecting the environment in which we live. I enjoy the satisfaction of delivering a project which people rely on in their everyday lives. Working on renewable energy projects helps ensure our actions today do not compromise the ability of future generations to sustain themselves.

# CREATING SPARKS FOR ENERGY



{ROLE MODELS} PHILLIPA CASSIE

## 8. HOW DID YOU GO ABOUT ENTERING INTO THIS CAREER/ GETTING EXPERIENCE AND DO YOU HAVE ANY ADVICE FOR SOMEBODY LOOKING INTO THE SAME CAREER?

I took advice from career advisors at school and with support from my school and parents; I secured two work experience placements and a summer job in an engineering office. This helped me decide which area of the industry I wanted to pursue. Do not be afraid to approach businesses for work experience as this can be essential in guiding you to your preferred subject area. Work hard, be punctual and open to learning new things. The work environment is very different to school so it's important to use your initiative, do not always wait to be asked, be proactive and ask if you can help.

## 9. WHAT ARE THE BEST/ WORST THINGS ABOUT YOUR JOB? WHAT DO YOU FIND MOST REWARDING ABOUT IT?

Long hours can be difficult, especially when it comes to work life balance. However, the big reward is seeing a job through to completion and commissioning the wind farm. Every day is different and presents new challenges.

## 10. WHAT ARE THE CHALLENGES OF YOUR JOB?

Customers are always challenging engineers to produce more sophisticated solutions for less money and in shorter timescales. These can often be unrealistic, and extremely challenging for offshore wind farms due to weather conditions. Helping the customer understand why there are certain technical limitations is really important.

## 11. WHAT HAS BEEN THE HIGHLIGHT OF YOUR CAREER SO FAR? WHAT HAS BEEN THE MOST EXCITING/ INTERESTING PROJECT YOU HAVE WORKED ON?

I was delighted to achieve Chartered Engineer Status. Working on the Ratcliffe Power Station Environmental Upgrade, the first project of its type in Europe, was also very exciting.

## 12. HOW DO YOU HOPE TO PROGRESS IN YOUR FIELD OVER THE COMING YEARS?

I'd like to stay in the technical side of my job as this is what I enjoy most. Maybe progress to either Engineering Manager for a similar project or move in to technical support management for the E.ON fleet (fossil or renewable).

## 13. WHAT PASSIONS AND INTERESTS DO YOU PURSUE IN YOUR PERSONAL TIME?

I have two horses which I compete nationally. I also enjoy running and ran my first marathon last year completing the course in 3hr 43mins.

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*STEMNET, 2nd Floor, Weston House, 246 High Holborn, London WC1V 7EX*

*T 020 3206 0450, E [info@stemnet.org.uk](mailto:info@stemnet.org.uk)*



{ROLE MODELS} CHRIS ABETIANBE

**NAME:** CHRIS ABETIANBE

**ORGANISATION:** RWE NPOWER RENEWABLES

**JOB TITLE:** RENEWABLES ENERGY DEVELOPER

## 1. WHAT DO YOU DO?

I am part of a Development Team which designs onshore wind farms.

## 2. DESCRIBE YOUR TYPICAL WORK DAY

I work with the internal project team and consultants who carry out environmental assessments and manage the technical, legal and commercial areas of the project as well as landowners/agents and statutory and non-statutory bodies to ensure a robust project is designed.

## 3. WHAT HOURS DO YOU WORK?

Normally 9am-5pm weekdays

## 4. WHICH SUBJECTS DID YOU ENJOY MOST AT SCHOOL?

Chemistry, Physics, Technical Drawing and Building Construction as they deal with the composition of all matter and how you can use this knowledge to create things to be used in our everyday activities, for example, in our homes, schools and hospitals.

## 5. WHAT QUALIFICATIONS DO YOU HAVE?

BEng in Chemical Engineering, and MSc in New & Renewable Energy

## 6. TO WHAT DEGREE WERE STEM SUBJECTS IMPORTANT IN GETTING YOUR JOB?

They were very important: Mathematics, Chemistry and Physics formed the foundation of my career by offering me a range of options in scientific and engineering fields. These subjects helped mould my skills and gave me the confidence to be proactive and ask the right questions when necessary. STEM subjects give you that edge as you have been trained to be flexible.

## 7. WHAT WERE THE MAIN FACTORS THAT ATTRACTED YOU TO YOUR CURRENT JOB ROLE AND HOW DID YOU GO ABOUT ENTERING INTO THIS CAREER AND GETTING EXPERIENCE?

My passion for renewable energy and its role in addressing climate change. Renewable energy is provided by nature so to me, this method of producing energy stands out as the way to address the world energy crisis. After my undergraduate degree, I worked in a financial institution briefly before completing my Masters. I then joined RWE npower renewables on an internship as a Graduate Developer designing offshore wind projects before moving into my current role. I was keen to work for RWE npower renewables as they are the leading renewable energy provider in Wales.

# CREATING SPARKS FOR ENERGY



{ROLE MODELS} CHRIS ABETIANBE

## 8. DO YOU HAVE ANY ADVICE FOR SOMEBODY LOOKING INTO THE SAME CAREER?

Take all STEM subjects seriously as they give you a solid background for a wide range of careers. These subjects open up opportunities in a wide range of fields and can even assist you in becoming an entrepreneur.

## 9. WHAT ARE THE BEST / WORST THINGS ABOUT YOUR JOB? WHAT DO YOU FIND MOST REWARDING ABOUT IT?

Working with specialists in many fields provides me with opportunities to learn interesting aspects of project development and how it fits into the 'bigger picture.' I meet with engineers, planners, lawyers, environmentalists, and members of the public and discuss how we can make our onshore wind projects more favourable to all whilst ensuring the long term objectives of energy security and low carbon fuels are met.

## 10. WHAT ARE THE CHALLENGES OF YOUR JOB?

Getting people to understand the need for renewable energy projects is tough, as is negotiating with specialists without getting too technical, and ensuring I can communicate issues to the rest of the team using simple language. Also, trying to incorporate everyone's opinions in the design!

## 11. WHAT HAS BEEN THE HIGHLIGHT OF YOUR CAREER SO FAR? WHAT HAS BEEN THE MOST EXCITING / INTERESTING PROJECT YOU HAVE WORKED ON?

I am glad that I contributed to the design of the 1200 MW Triton Knoll Offshore Wind Project and 96 MW Clocaenog Forest Onshore Wind Project, as well as the design of the Durham University Solar car, the only British solar car to represent the UK in the Global Solar Car Challenge in 2008.

## 12. HOW DO YOU HOPE TO PROGRESS IN YOUR FIELD OVER THE COMING YEARS?

I hope to use my experience to continue developing wind projects and preparing new projects for construction. I also hope to continue working with other key players in the wind industry and renewables sector to ensure the UK meets its 2020 EU renewable energy targets.

## 13. WHAT PASSIONS AND INTERESTS DO YOU PURSUE IN YOUR PERSONAL TIME?

Watching and analysing football, reading and playing chess. I'm a keen volunteer in my local community supporting activities including fundraising for my local church, doing some weeding to help preserve my local nature centre and supporting young people through the STEM Ambassadors Programme.

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