

GCSE RESOURCES FOR TEACHERS



South East Physics Network **GCSE Programme**



SEPnet (South East Physics Network) is a consortium of university physics departments. To find out more about SEPnet's work please see our website www.sepnet.ac.uk

The following classroom activities have been developed from SEPnet's GCSE programme. The activities are designed to use inexpensive equipment and tie in with the key themes for KS4 in England and Wales.

The large majority of the equipment needed for these activities can be found through online suppliers such as Amazon and eBay.

All individual items listed can be bought for under £20 at the time of going to print (Spring 2013).

All activities should be risk assessed when delivering them in the classroom. Specific risks, such as the use of laser pointers, have been identified under the individual activities.

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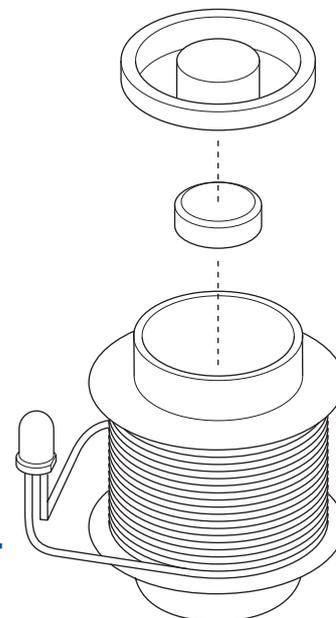
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SHAKE-A-GEN

By using a film canister, some wire and a magnet you can generate enough electricity to power an LED.

EQUIPMENT

LED
Thin insulated copper wire
35mm film canister
Small strong magnet (to fit inside the film canister)
Cardboard
Sticky tape



INSTRUCTIONS

- 1 Remove the lid from the film canister.
- 2 Cut out two cardboard circles about 50mm diameter. Then cut out their centres making a 33mm diameter hole.
- 3 Push the film canister through these cardboard disks and space them about 3cm apart. Use the sticky tape to hold them in place.
- 4 Keep about 10cm of wire free at the beginning, then wind 500 to 1000 turns of the wire around the canister between the cardboard disks. Leave another 10cm of wire free at the end and hold the coil in place with more sticky tape.
- 5 Remove about 5mm of the insulation from the ends of the wire and connect to the LED – solder the connections if possible. Then attach the LED to the bottom of the film canister with sticky tape.
- 6 Pop the magnet into the canister and snap the lid back on.
- 7 Hold the canister between your thumb and forefinger at the two ends to stop the lid coming off and shake. The LED will light.

BACKGROUND

An electric current is generated in a conducting wire when it moves in a magnetic field, or in this case, when a magnet (and its magnetic field) moves inside a coil of wire. The magnetic field exerts a force on the electrons in the wire, causing them to move. This is known as induction.

To generate more current in the circuit, you need to have a stronger magnet, more coils of wire, or move it faster. As the magnet moves from one end of the coil to the other it produces an alternating current.

TIPS FOR SUCCESS

You can use a bi-coloured LED to help illustrate the alternating current produced. This will light one colour when the magnet moves in one direction and another colour when the magnet moves in the other direction. Small but very strong magnets, such as Rare Earth magnets, can be found online from electronics shops or magician suppliers (strong magnets are often used for magic tricks). 35mm film canisters can be quite hard to find, but try a specialist photography shop as they often keep them from the film they develop.

This activity was developed by Dr Jonathan Hare, Creative Science
www.creative-science.org.uk/gensimple1.html

ELECTROSTATIC DRINKS CAN

This simple activity is a great way of illustrating how electrons can move from one material to another.

EQUIPMENT *An empty drink can*
Balloon

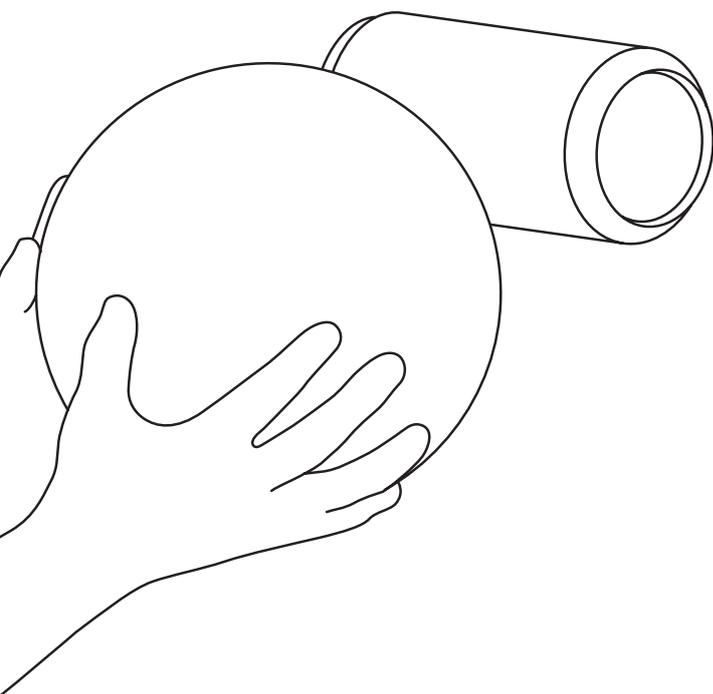
- INSTRUCTIONS**
- 1 Take an empty drink can and a blown up balloon.
 - 2 Rub the balloon on your head or clothes.
 - 3 Place the can on a table and hold the balloon close to the can (about 2cm away).
 - 4 The can will roll towards the balloon
-

BACKGROUND When you rub the balloon against your head or clothes, negatively charged electrons are transferred onto it. The rubber balloon is an insulator so the electrons can't flow through it, instead they sit near the surface wherever they have been deposited.

The electrons in the metal drink can are able to move. When the negative charge from the balloon comes near the drink can the electrons in the can are repelled and flow away, leaving only the stationary positive charges – the centres of the metal atoms – behind.

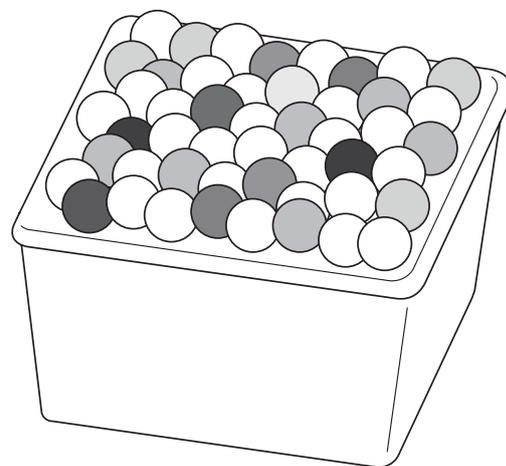
These positive charges in the can are attracted to the negatively charged balloon and want to move towards it, but because they are fixed in place the whole can moves towards the balloon!

TIPS FOR SUCCESS Don't let the can touch the balloon, but slowly move the balloon away as the can rolls towards it, keeping a gap of a couple of centimetres.



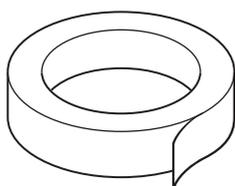
PUPIL CIRCUIT

In this activity, students move around the classroom in a circuit taking energies from a battery to a bulb.



EQUIPMENT *Plastic tubs*
Balls (such as children's ball pool balls)
Chalk or masking tape

- INSTRUCTIONS**
- 1 Clear an area of the classroom, or use a hall or playground space. You can mark out the circuit diagram you are trying to represent either in chalk if you are outside, or masking tape on the floor if you are inside.
 - 2 Ask one of the students to be a battery and give them a tub of balls. These represent the stored energy of a battery. Ask another student to be a light bulb. Give them an empty tub and have them stand on the other side of the classroom to the battery.
 - 3 Set the rest of the class up in a series circuit to transfer the energy from the battery to the bulb. Each student picks up a ball (an energy) from the battery, walks to the bulb and places it in the bulb's tub. They will need to move in single file and straight lines as they are confined to wires. The students are the electrons in a circuit.
 - 4 Once they have returned to the battery they should no longer have any energy so need to be re-energised by the battery and pick up another ball.
 - 5 Add another battery in series. The students receive two energies – one from each battery – and give both to the bulb. At the end the bulb will have received twice as much energy in the same time – meaning it will be brighter.
 - 6 Add another bulb in series in this circuit and instruct the students to give one energy to each bulb. The amount of energy received by each bulb is now the same as in the first circuit you made.
 - 7 Set up a parallel circuit with a bulb on each branch. The students should now take one branch and deposit both their energies into that bulb tub before returning to the battery. You will need to get the students to move more quickly, representing how the current increases in a parallel circuit.



BACKGROUND In a series circuit the potential difference from the battery is shared between components, but in a parallel circuit each component has the same potential difference. How much energy the bulb uses every second (and therefore its brightness) depends on this potential difference. So lots of bulbs in series, all sharing the batteries' potential difference, will be dimmer.

You can have as many bulbs as you want in parallel with the battery and they will all be as bright as if there was just one. In parallel the battery has to deliver a lot more energy to these bulbs so the battery runs down more quickly.

TIPS FOR SUCCESS This activity can be extended to explore and discuss different properties of electricity and circuits. You can add a resistor to the circuit by asking someone to try and block the path of the electrons. Students can limbo under a resistor which requires more energy than walking. This can help reinforce the concept that resistors require energy and students will need to give one of their energies to the resistor. You can also add a diode into the circuit. The students can only pass through the diode in one direction.

ROLLERCOASTER PHYSICS: LOOP THE LOOP

This activity uses ball bearings and insulation foam to build a simple rollercoaster loop the loop.

EQUIPMENT

LED

4m pipe insulation foam (or shorter lengths that can be taped together)

Large ball bearings (12mm or 14mm) or marbles of known mass

Strong sticky tape

Scissors

Data loggers, light gates and measuring tapes

INSTRUCTIONS

- 1 Cut the insulation foam in half lengthways. The foam will come with a slit already cut down one side; use scissors to cut the other side so that you have two pieces.
- 2 Shape the foam into a loop about 1.5m along the length. Tape this loop at the base so that it doesn't unravel. You will need to make sure that the tape doesn't block the track, but you can tape down into the dip in the foam so the ball can roll over it.
- 3 You should have a longer section on one side of the loop which forms the down ramp.
- 4 Lift the ramp and tape this to a table or chair, then secure the loop to the floor with some tape.
- 5 Send ball bearings down the ramp so that they complete the loop.

BACKGROUND

This is great as a way to show students how potential energy converts to kinetic energy and back to potential energy again. When the ball is released from the ramp it has gravitational potential energy.

Potential Energy: $GPE = mgh$ ($m = \text{mass}$, $g = \text{gravitational field strength}$, $h = \text{height}$)

Students can work this out by measuring the height that the ball is released from. With light gates the students may want to measure the velocity of the ball at the base of the ramp, just before the loop, and calculate the kinetic energy.

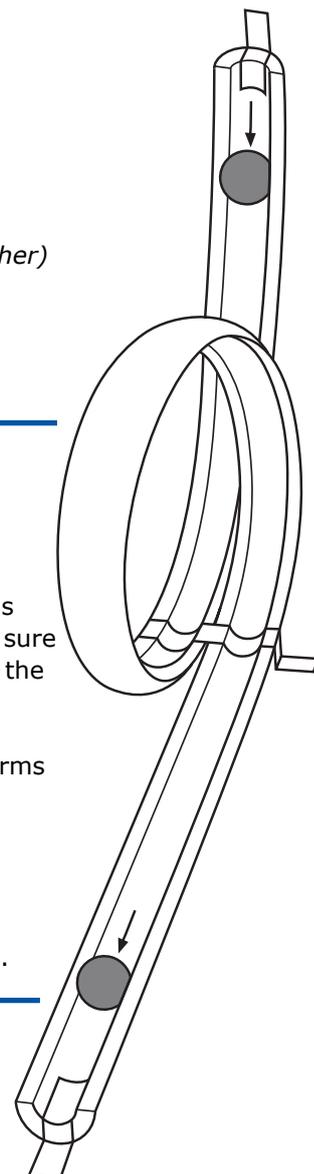
Kinetic Energy: $KE = \frac{1}{2}mv^2$ ($m = \text{mass}$, $v = \text{velocity}$)

As the ball goes around the loop, some of its kinetic energy is converted back into potential energy as it is lifted away from the floor, but crucially it must retain enough kinetic energy to adhere to the laws of circular motion – too slow and it will fall off before it completes the loop.

Students can look at the amount of energy the ball has at intervals around the track. This could lead to discussion about how energy is lost as the ball travels along the track.

TIPS FOR SUCCESS

You can compare loops made of different material, for instance plastic siphon tubing used for brewing beer slit down one side so that it forms an open channel. Or try balls with different masses.



CONVECTION TEABAG

This impressive demonstration makes a sky lantern out of an empty teabag.

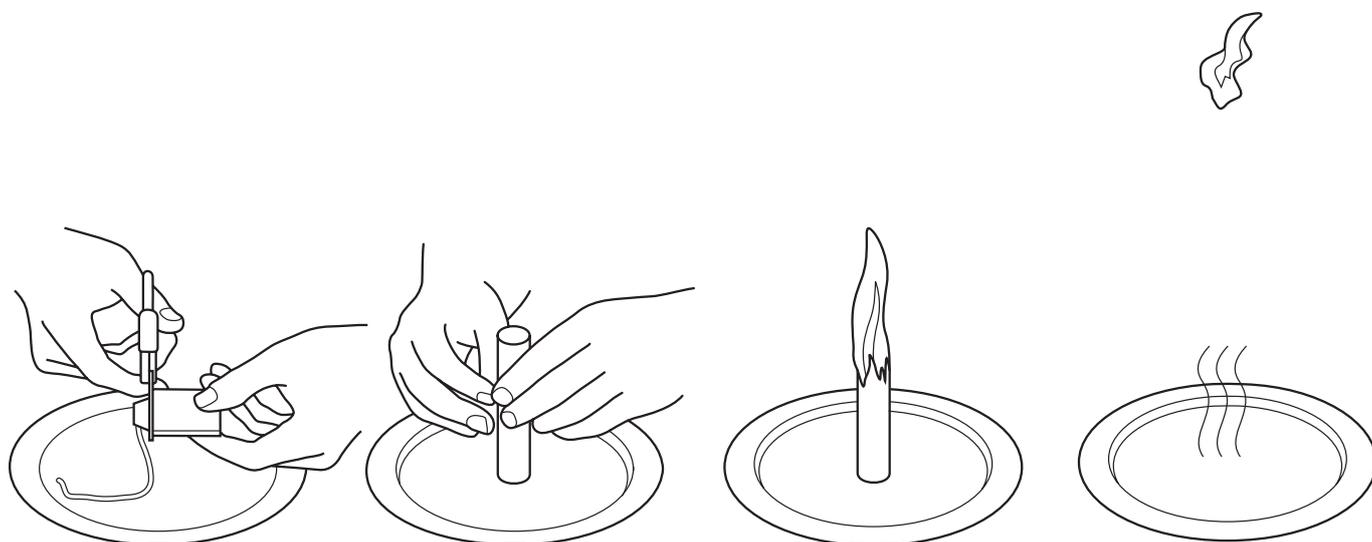
EQUIPMENT *A square teabag*
Matches
Scissors
Dinner plate

- INSTRUCTIONS**
- 1 Cut off two ends of the teabag and empty the contents. You should be left with an empty tube.
 - 2 Make this tube into a cylinder and stand it on one end on the plate.
 - 3 Use a match to light the top of the cylinder.
 - 4 Stand back and watch as the bag burns down and the remains of the bag float into the air.
-

BACKGROUND As the flame burns down the teabag, it heats the air within the cylinder. The warmer air molecules inside the cylinder move more quickly and spread out, making the air inside the cylinder less dense than that air outside it. The less dense hot air rises and the space created allows the cooler more dense air to push upwards from the bottom creating a convection current.

TIPS FOR SUCCESS You could extend the activity to discuss other things that make use of convection such as radiators in the home, sky lanterns, hot air balloons and even convection currents in the atmosphere that help create clouds.

You could also use a toaster, cardboard box and plastic bag to create a hot air balloon. Place a cardboard box with both ends open over the toaster and hold the plastic bag over one of the open ends. Turn the toaster on and watch as your plastic bag fills with warm air, then after a few seconds let go of the bag and it will float up to the ceiling.



HOUSEHOLD ENERGY DEMANDS

With this activity you can calculate how much energy different household appliances use over the course of a day.

EQUIPMENT

Energy monitors
Lamps – one with an incandescent bulb
the other with an energy saving bulb
Laptop
Phone charger
Toaster

INSTRUCTIONS

- 1 Plug each appliance into the energy monitor in turn and read how much power in watts the appliance uses. If the reading fluctuates then take a series of readings over a minute (e.g. once every 10 seconds) and calculate the average.
- 2 Once you have readings for all of the appliances, estimate how many hours a day each appliance would run for.
- 3 From this you can find out which appliance would use the most energy in one day by calculating the number of kilowatt hours used: $\text{Energy transferred (kW h)} = \text{power of device (kW)} \times \text{time in use (hours)}$
- 4 Given the cost of electricity (e.g. 20p per kilowatt hour), you can then calculate how much would it cost to run an appliance over the course of a day: $\text{Total cost} = \text{number of kW h used} \times \text{cost per kW h}$

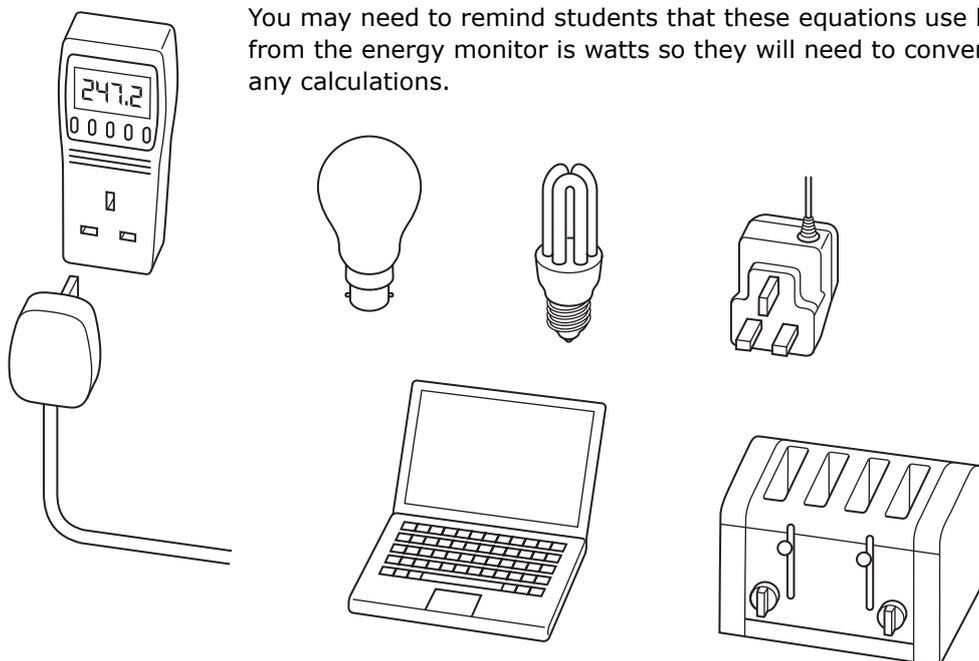
BACKGROUND

Energy usage is measured in kilowatt hours; this is the unit that is quoted on energy bills. Once students have calculated the kilowatt hours used for each appliance they can compare them. Which would cost less to run, an incandescent bulb or the energy saving bulb?

TIPS FOR SUCCESS

Inexpensive energy monitors can be found online and you can either use a single monitor and plug in each appliance in turn, or use more than one monitor and plug in all appliances at the same time and circulate groups of students round each to take readings.

You may need to remind students that these equations use kilowatts but the readings taken from the energy monitor is watts so they will need to convert their readings before they do any calculations.

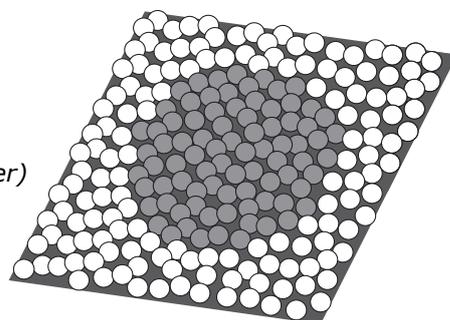


COLOUR CHANGING CONDUCTION PLATE

Ball bearings, polystyrene balls and a liquid crystal sheet can be used to reveal beautiful patterns when heated up.

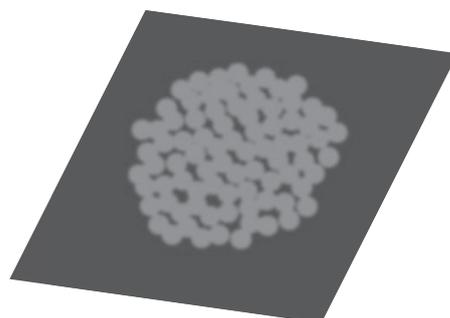
EQUIPMENT

Ball bearings (approx 5mm)
Polystyrene balls (similar size as ball bearings)
Self-adhesive liquid crystal thermochromic sheet
Microwaveable hot water bottle (without the fabric cover)
Sponge
Some water



INSTRUCTIONS

- 1 Remove the film from the back of the liquid crystal sheet to reveal the sticky layer.
- 2 Place the ball bearings onto the sticky layer in a pattern such as a circle or square, or even a smiley face.
- 3 Cover the rest of the sticky layer with polystyrene balls.
- 4 Heat up the hot water bottle.
- 5 Place the sheet, with the ball bearings and polystyrene balls face down, onto the hot water bottle. The entire sheet should heat up and change colour.
- 6 Once it has heated up so that it is all the same colour, wet the sponge and wipe a layer of water over the top of sheet. This will cool down the surface enough to reveal a pattern of hot spots caused by the ball bearings conducting heat from the hot water bottle. The cooler areas are those insulated by the polystyrene balls.



BACKGROUND

You can use this activity to discuss conduction and insulation, and evaporation from the water cooling the surface.

When the heat is initially applied the entire sheet will heat up, but if you cool down the surface of the sheet with some water then the hot spots of the ball bearings are revealed. Metals are good conductors of heat whereas the polystyrene balls act as an insulator. This difference in heat causes the liquid crystal sheet to change colour.

Liquid crystal molecules change position or twist according to changes in temperature. This change in molecular structure affects the wavelengths of light that are absorbed or reflected by the liquid crystals.

TIPS FOR SUCCESS

The ball bearings can take a little while to heat up, but once they do they will conduct heat from the hot water bottle well. If the heat is very high the polystyrene balls will let some heat through, but once it has cooled down they will provide a good layer of insulation. You may need to blow onto the wet surface of the sheet to cool it down, or position a desk fan to cool it, especially if the heat supply is very hot.

HYDROELECTRICITY

Turn some plastic spoons into a mini water wheel to help explore hydroelectricity.

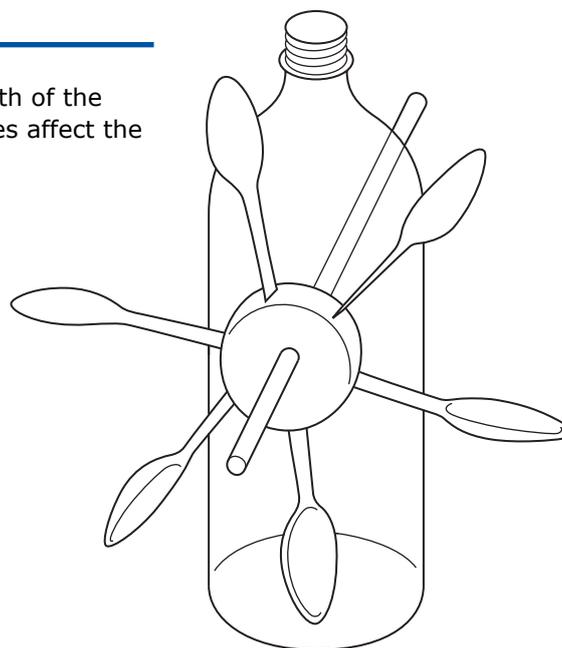
EQUIPMENT *An empty 2 litre plastic bottle*
Drinking straw
Modelling clay
Plastic spoons
Metal nut, or other small weight
Thread

- INSTRUCTIONS**
- 1 Make a table tennis sized ball of modelling clay by rolling it in your hands, then press it flat into a fat disk.
 - 2 Stick the handle ends of the spoons into the edge of the disk with the spoon end facing outwards and all facing the same way so that they form scoops to catch the water. This will form the water wheel.
 - 3 Push one end of the straw through the middle of your wheel. The rest of the straw is the shaft of the wheel.
 - 4 Make two holes either side of the bottle about two thirds of the way up and push your straw through the bottle. The wheel should now be attached to the bottle like a windmill.
 - 5 Hold the spoons under running water so that the stream hits each of the dips of the spoons. The shaft should turn.
 - 6 Tie a weight or metal nut to the end of a thread and attach the other end of the thread to the end of the straw shaft sticking out of the bottle. As the wheel turns, the thread should wind round the shaft and lift the weight.
-

BACKGROUND Water wheels like this are used to generate electricity: they convert the water's kinetic energy into electrical energy. In this case the water wheel is used to convert kinetic energy into potential energy, as the weight is lifted.

TIPS FOR SUCCESS Vary the number of spoons used and the length of the spoon handle to investigate how these changes affect the speed of the wheel.

You may need to fill the bottom of the bottle with some water to help weigh it down, and put a blob of modelling clay on the end of the straw to stop the water wheel sliding off.



INFRARED CAMERA

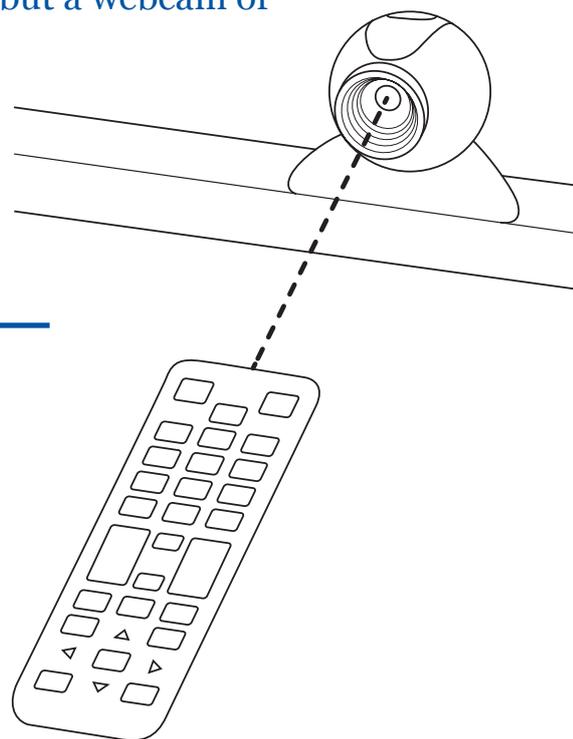
Infrared radiation sits outside the visual spectrum, but a webcam or digital camera can help you see infrared at work.

EQUIPMENT

- Infrared LEDs or a remote control
- Lithium batteries
- Webcam or digital camera
- Black bin bag
- Infrared filter

INSTRUCTIONS

- 1 Attach the infrared LED to the battery.
- 2 Position it so that it points at the webcam. Although you won't be able to see it with the naked eye, you should be able to see it shining on the webcam. If you are unable to use a webcam then a digital camera will give you similar results.
- 3 Put the bin bag between the LED and the webcam. The LED should still be visible. This also works with a remote control.
- 4 Take an infrared filter and place in front of the lens. Turn down the lights and use the remote control or LED as an infrared torch. Then look through the webcam or camera to see things in 'night vision'.



BACKGROUND

Most webcams, digital cameras and smartphone cameras detect electromagnetic radiation at a wider range of frequencies than the human eye. This allows them to detect infrared radiation in addition to the visible range. A black bag absorbs all visible radiation, which leads it to appear black, but it does not absorb infrared radiation so this can still be seen through the bag.

TIPS FOR SUCCESS

For best results, remove the filter from the webcam and replace it with one that only allows infrared through. However, this only works with old webcams as it is usually too difficult to remove the filters on the newer models. For more information see www.instructables.com/id/Making-a-Night-Vision-Webcam

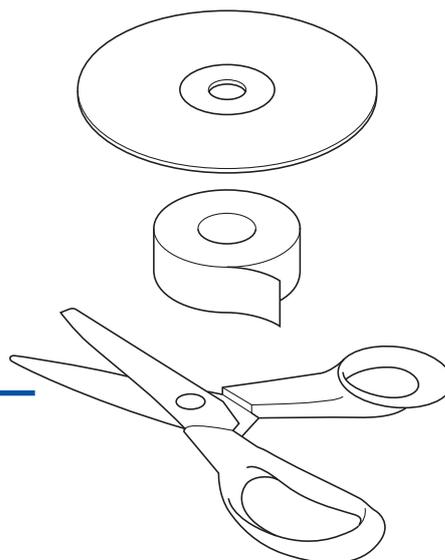
Inexpensive infrared filters for digital cameras can be purchased online. Hold it in front of the lens to take infrared images.

If you live in the South East then SEPnet have infrared thermal cameras that you may be able to borrow. To find your local SEPnet partner see www.sepnet.ac.uk

BUILD A SPECTROSCOPE

You will need to use a template printed onto card and a handful of old CDs to make these spectroscopes.

EQUIPMENT *Thin card*
Spectroscope template (available online with this pack)
CD
Scissors
Sticky tape



- INSTRUCTIONS**
- 1 Print the template onto card.
 - 2 Cut the two 60° slots to the edge of the card.
 - 3 Gently poke a pencil through the card for an eye hole. This is easier if you use some modelling clay to push the pencil in.
 - 4 Cut out the outline of the template and cut the slit out. The slit needs to be wider than just one cut.
 - 5 Roll the template to make a tube and use the tabs and tape to stick down the disk blocking all other light.
 - 6 Place a CD in the 60° slots and point the slit directly towards a light source. You should be able to see a rainbow spectrum on the CD when you look through the eyehole.

BACKGROUND

A CD has narrow ridges in it, where the data is stored. These ridges behave like a diffraction grating so that when light reflects off it, the light is split into its constituent colours. If you look at an incandescent light you will see a continuous spectrum because the light comes from a hot filament, producing a full spectrum of light from red to blue.

Sometimes a spectrum can have bright or dark bands in it. These bands can tell us what the light source is made of, or what the light has travelled through. A fluorescent light may produce two or three bright bands within its spectrum. These are caused by the mercury atoms that are inside the fluorescent tube.

TIPS FOR SUCCESS

Enlarging the slit will make the spectra less faint but if too much light gets in, the spectra will not be clear.

Take care when pointing the spectroscope at very bright light sources such as the Sun.

MEASURING THE SPEED OF LIGHT IN A MICROWAVE

With a few marshmallows, a ruler and a microwave oven you can calculate the speed of light

EQUIPMENT

Microwave
Chopping board/piece of cardboard of a size that will fit into the microwave
Marshmallows (or cheese slices or chocolate buttons)
Ruler

INSTRUCTIONS

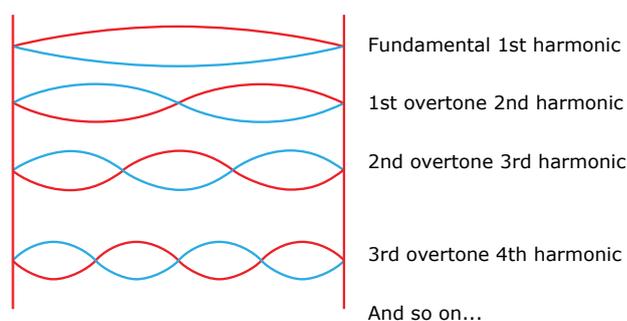
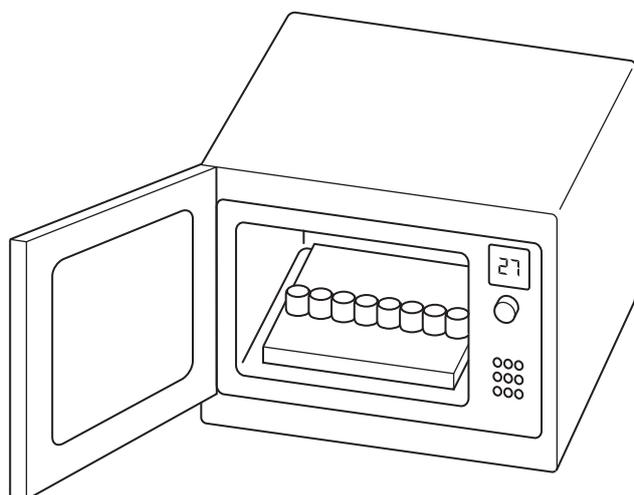
- 1 Take the turntable out of the microwave (ensuring that the microwave will still work like this!).
- 2 Line up marshmallows along the chopping board so they will form a line from left to right when in the microwave. The marshmallows should be just touching.
- 3 Place the board in the microwave and turn it on. As soon as one of the marshmallows starts to melt, switch it off again.
- 4 Measure the distance between the two most melted marshmallows (or the two least melted). This distance is half a wavelength.
- 5 Multiply the distance by two to give you a full wavelength and look for the frequency of the microwave which is often written on the back of the microwave.
- 6 Using these measurements, calculate the speed of light using the wave equation:
 $speed (m/s) = frequency (Hz) \times wavelength (m)$

BACKGROUND

The sides of the microwave are reflective and so they set up a standing wave, with nodes and antinodes. At the nodes, there is no wave amplitude. These are spots in the microwave that never receive the microwave energy, and are the points where the marshmallows are least melted. The antinodes have the most energy and are where the marshmallows are most melted. If there was no turntable in a microwave, these nodes and antinodes would lead to uncooked and burnt patches in a meal!

TIPS FOR SUCCESS

Turn the microwave off as soon as the marshmallows start to melt, once they start to melt they melt very quickly. Ensure all students are using the right units when calculating the speed of light.



ULTRAVIOLET LIGHT

With an inexpensive ultraviolet torch, some sunscreen and laundry detergent you can explore the properties of ultraviolet (UV) light.

EQUIPMENT

- UV torches*
- UV reactive beads*
- Petri dishes*
- Sunscreen*
- Moisturiser cream*
- Liquid laundry detergent*
- White paper*
- £10 and/or £20 banknote*

- INSTRUCTIONS**
- 1 Apply sunscreen to a few of the beads, but don't let the students know what the cream is.
 - 2 Place some of these beads along with some that haven't got sunscreen on them in a petri dish and hand them out to the class. Ask the students to shine the torches on the beads and ask for suggestions on what the cream might be.
 - 3 Take two pieces of white paper and rub some of the sunscreen on one, and some of the laundry detergent on the other (don't let the students know what this liquid is).
 - 4 Hand these round and ask the students to shine the torches onto the paper. The sunscreen will appear dark against the white paper, but the laundry detergent will fluoresce. Ask the students for suggestions of what this might be.
 - 5 Use the torches to reveal the UV markings on banknotes, credit cards and driving licences.
-

BACKGROUND

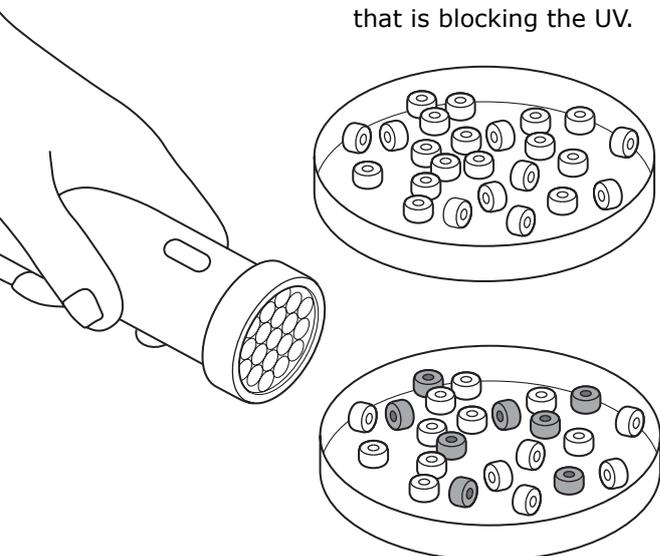
Ultraviolet light has a shorter wavelength than visible light. Sunscreen blocks UV light from the sun to prevent sunburn, but laundry detergent contains optical brighteners that fluoresce under UV (absorb some of the ultraviolet light and re-emit it as visible light) making your clothes look 'whiter than white' in the daylight.

TIPS FOR SUCCESS

When applying sunscreen to the UV beads you can also apply moisturising cream (without SPF protection) to the other beads so that students know that it is something in the cream that is blocking the UV.

Most laundry detergents contain optical brighteners, although the environmentally friendly brands tend not to use them.

Take care as some students may have allergies to sunscreen or washing liquid. You can hand out the beads covered in cream in a petri dish and wear gloves to handle the washing liquid.

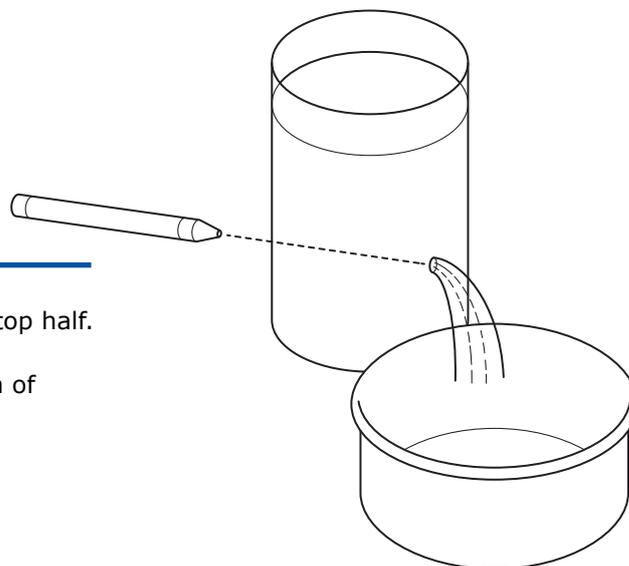


TOTAL INTERNAL REFLECTION

This activity takes a bit of setting up but can be used to demonstrate total internal reflection when discussing fibre optics.

EQUIPMENT

Water
1.5l clear bottle
Laser pen
Sticky tape
Bowl



INSTRUCTIONS

- 1 Cut the bottle in half and discard the top half.
- 2 Make a small hole towards the bottom of the bottle.
- 3 Tape over the hole.
- 4 Fill the bottle with water.
- 5 Take the tape off the hole and let the water flow into the bowl below.
- 6 Immediately point the laser pen through the bottle so it is in line with the hole. The light will be totally internally reflected within the stream of water flowing out of the bottle.

BACKGROUND

When light moves from a substance with a higher refractive index (like water) to one with a lower refractive index (like air), the light bends. If the direction of the light is almost parallel with where the two substances meet, the light can bend enough so that it is effectively reflected back inside the material. This is known as total internal reflection. The light bounces back at the same angle it tried to escape at and can end up bouncing off the other side of the material in the same way, trapping the light inside.

This is the principle on which optical fibres are based. Total internal reflection allows the light to pass along a twisting glass fibre without the light escaping.

TIPS FOR SUCCESS

Some light from the laser pointer will escape from the stream of water, but if you make the room darker then you should be able to see the light being reflected within the stream of water from the bottle to the bowl.

You can buy an inexpensive USB endoscope online which can also be used to help demonstrate total internal reflection. Use the endoscope to see places you can't usually get to!

Take care not to shine the laser pointer in anyone's eyes. Please be aware of the power of the laser pointer and check with your school policy. Some low power laser pointers are available. Another alternative is to coat the bottle in silver foil or black paper, have a ray box on one side with a colour filter – if the bottle is enclosed enough and the room is fairly dark then you can easily see the light from the ray box trapped within the stream of water.

WHAT'S IN THE BOX? ULTRASOUND

A handful of skewers and a cardboard box can help your students explore the principles of ultrasound.

EQUIPMENT *Cardboard box*
Wooden skewers (these need to be able to reach from the top of the box to the bottom)
Small doll or other object

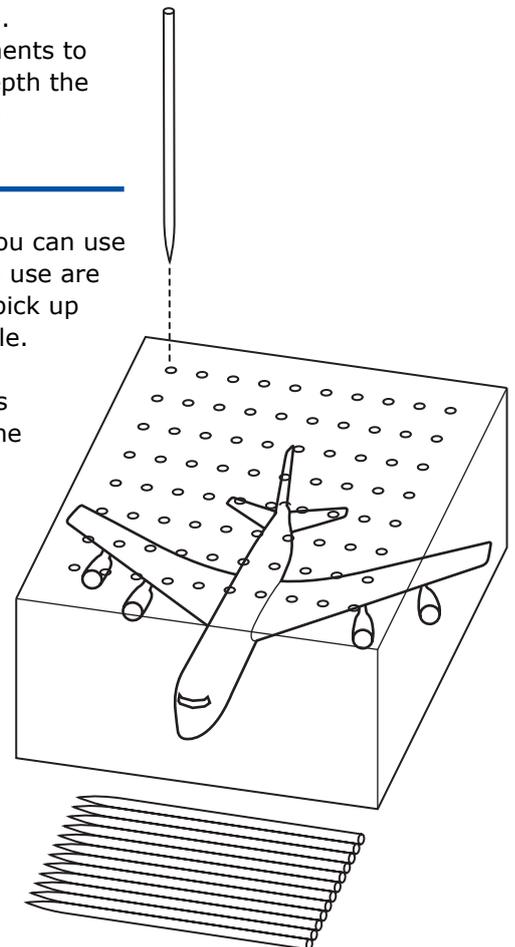
- INSTRUCTIONS**
- 1 Make a grid of holes in the top of the cardboard box.
 - 2 Place the doll inside the box.
 - 3 Give the sealed box and skewers to the students.
 - 4 The students should gently place a skewer in each of the holes and measure how deep it will go. They could sketch this on squared paper to help keep track of their measurements.
 - 5 From this they should try and guess what is in the box.
-

BACKGROUND When ultrasound waves meet a boundary between different materials, some of them are reflected. Ultrasound machines measure the time between the wave being sent and returning, and use that to find the depth it was reflected from. A computer can then put together these measurements to create a picture of what is inside. Measuring the depth the skewers go to can be used to model the ultrasound measurement.

TIPS FOR SUCCESS The sticks should go into the box at right angles. You can use any object to place in the box, but the best ones to use are those without many small ridges (the sticks won't pick up fine detail) and something that is easily recognisable.

If you wish to demonstrate the use of ultrasound as well, ultrasound tape measures can be bought online for about £20. You can also use smaller boxes and cocktail sticks if you want to do a smaller version of this activity.

The students should **take care** when pushing the skewers through the box as sharp skewers could go through the cardboard.



RADIOTHERAPY

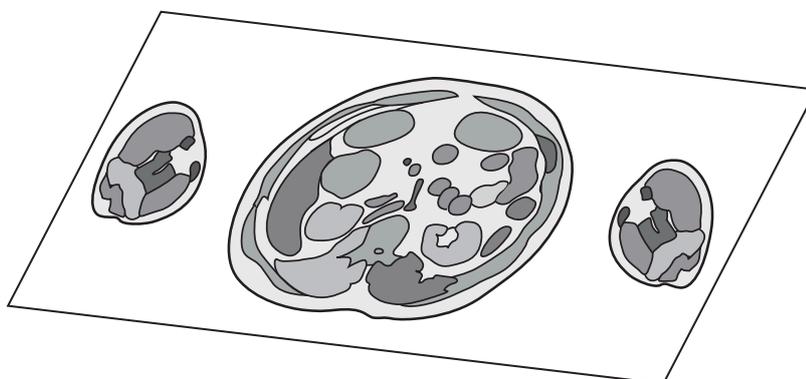
Students layer acetates to simulate radiotherapy treatment with this inexpensive activity.

EQUIPMENT Radiotherapy 'wedges' printed onto acetate
(available online with this pack)
Human cross section

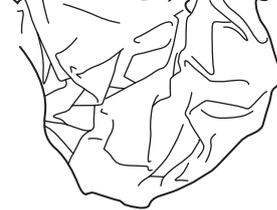
- INSTRUCTIONS**
- 1 Print off the pictures of wedges in different shades of grey onto acetates.
 - 2 Print a CT (computed tomography) human cross section scan from Loyola University Chicago website
www.meddean.luc.edu/lumen/MedEd/grossanatomy/x_sec/mainx_sec.htm
 - 3 Mark an area on the cross section to be the tumour.
 - 4 Give the students the picture and set of acetates.
 - 5 They have to arrange the acetates to completely black out (kill) the tumour without blacking out any of the surrounding tissues.
-

BACKGROUND Radiotherapy uses targeted doses of radiation from different directions to ensure that the tumour gets a critical dose of radiation, while the surrounding areas get less to avoid killing them. Different parts of the body have a different critical dose, with organs being more susceptible to radiation than skin and extremities. This means that the location of the tumour can make radiotherapy very difficult, particularly if it is in the chest area.

TIPS FOR SUCCESS This activity can be used with others to discuss the role of physics in medical treatments. You can find many more activities on the National STEM Centre website:
www.nationalstemcentre.org.uk/elibrary/collection/565/teaching-medical-physics



NUCLEAR FISSION EXPERIMENT



This simple activity can help illustrate a nuclear chain reaction, but you will need to factor in some tidy-up time!

EQUIPMENT *Paper*
Plastic tubs

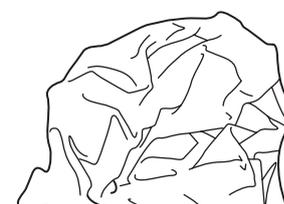
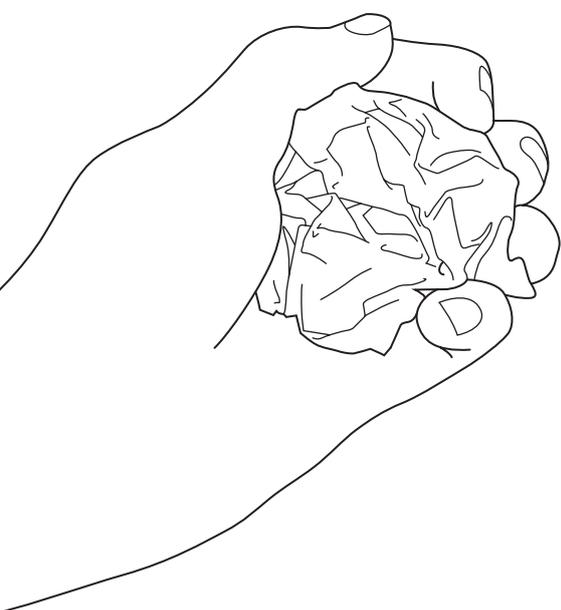
- INSTRUCTIONS**
- 1 Give each student two sheets of paper.
 - 2 The students should screw up their sheets to make two balls of paper.
 - 3 One student starts and throws their balls of paper at two students.
 - 4 The students who are hit then throw their two balls at two students each.
 - 5 Step 4 repeats until everyone has thrown their balls of paper.
-

BACKGROUND When a uranium nucleus undergoes fission, it gives off two energetic neutrons. These neutrons then collide with other uranium nuclei, triggering their fission reactions. These reactions in turn give off neutrons, leading to a chain reaction.

TIPS FOR SUCCESS You can extend this activity to include moderator rods. To prevent a chain reaction occurring, nuclear power stations have moderator rods which absorb lone neutrons. This prevents the neutrons from hitting other nuclei and slows the reaction.

To create a continuous chain reaction the students pick up and throw two more balls of paper from the floor every time they are empty handed and are hit again with another paper ball. You can then introduce moderator rods by asking a few students (about five students from the class) to pick up the balls that fall on the floor instead of throwing them. This will create a managed slower reaction.

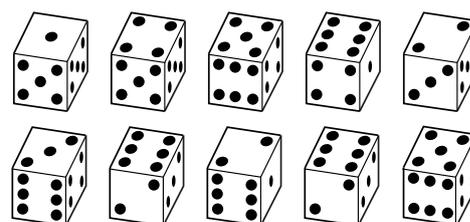
You can set this activity up with the moderator rods in place to begin with if you have a lively class. This will help keep things more under control.





HALF LIFE

This class activity helps to illustrate radioactive decay with the roll of a dice!



EQUIPMENT

Ten six-sided dice per student
Ten ten-sided dice per student

INSTRUCTIONS

- 1 The set of dice models a sample of radioactive rock with each die representing one atom. If the die lands on 6 then it is considered to have decayed to a daughter nucleus and is removed from the radioactive sample.
- 2 To start, give each student ten six-sided dice. Each student should roll all ten dice at once.
- 3 Any dice that lands on a 6 should be counted and removed. Students should make a note of how many land on a 6 during that roll.
- 4 The remaining dice should be rolled again, those landing on a 6 counted and removed. This should be repeated until the students have run out of dice or the student has rolled the dice ten times, whichever comes first.
- 5 The students can then use their results to plot a graph of the number of remaining dice against the roll number and use this to calculate the half-life of their dice. (E.g. Roll0 = 10, Roll1=8, Roll2=7, Roll3=5, Roll4=5, etc.).
- 6 The class results can be collated to produce a graph which is less random.
- 7 Ten-sided dice can be used to show the difference in half life with probability.
- 8 They can also be given different numbers of dice to show the size of sample does not affect the half life.



BACKGROUND

The half-life of a radioactive element is the time it takes for half the original material to change into something else (leaving half the original sample). The half-life of the dice is the number of rolls it takes for half the dice to have produced a 6 (leaving half the number of dice the student started with). If the student started with ten dice, how many rolls did they make before they ended up with just five dice remaining?



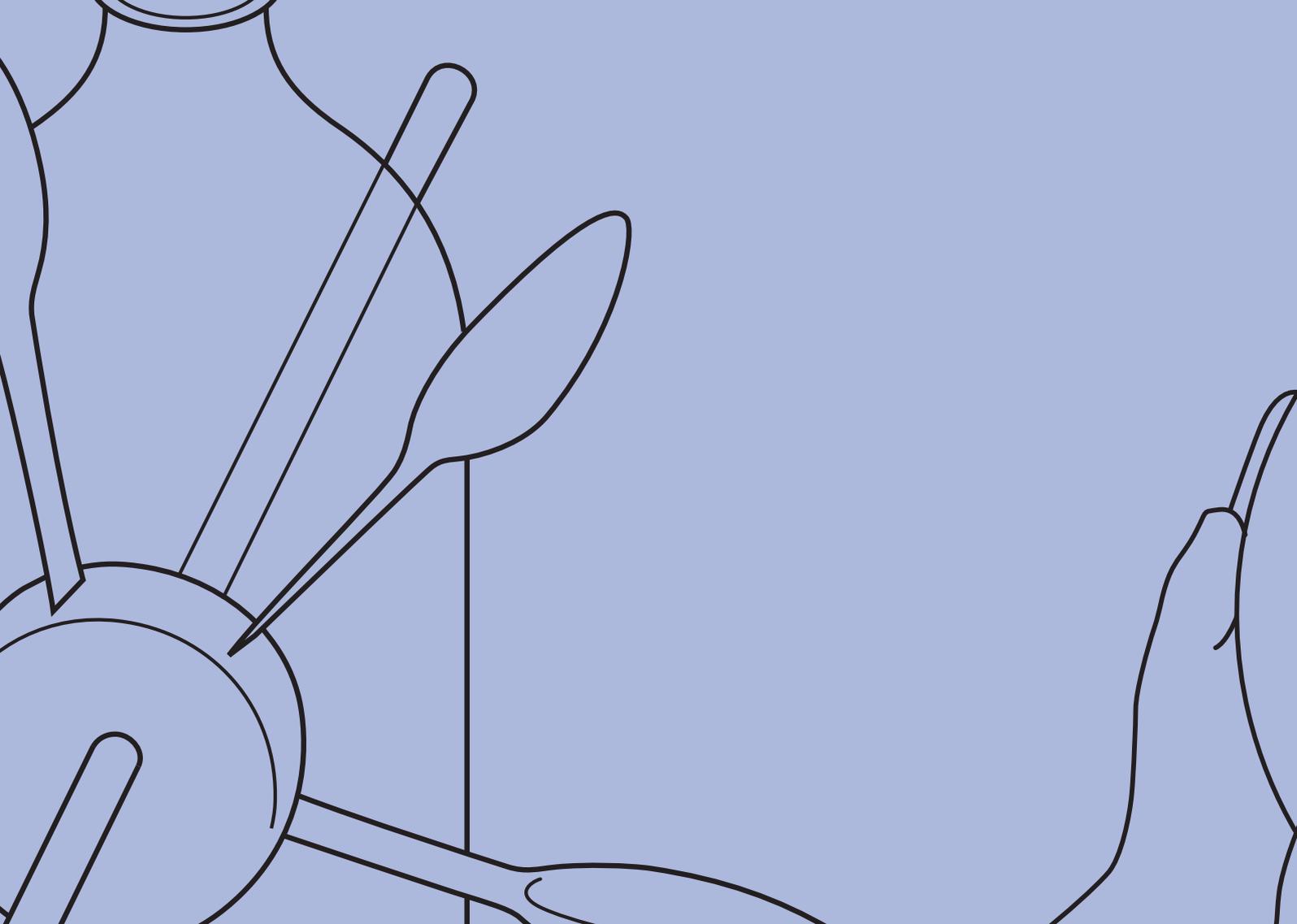
The half-life of an element is determined by the probability of decay of a single atom and different sample sizes do not affect the half-life. As with atoms, the dice have a fixed probability of rolling a 6 (decaying) and using dice with different numbers of sides can show that this is related to half life. The decay of an individual atom is random, as with the dice, but when looking at a large sample the probability produces predictable results.

Geologists use radioactive decay to determine which isotopes are present in rock samples. You can create a mixed sample of six-sided and ten-sided dice to show how the amount of each isotope (dice) changes over time.

TIPS FOR SUCCESS

Using ten-sided dice the students will get mixed results, but if you add the whole class results together, the curve produced will be much smoother. Inexpensive ten-sided dice can be bought online or from education suppliers.





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South East Physics Network **GCSE Programme**

www.sepnet.ac.uk/outreach/schools/gcse_programme.html



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