Fusion 1: P2.1 – Forces and Energy

National Curriculum Link up
•2.1a, b, c. 3.1a, b. 3.4c.

Electronic resources: Learning objectives, Practical worksheets, Plenary activity – Getting stronger, Homework activities A and B – Different types of forces

Learning Objectives
Pupils should learn:
That forces act between objects and can cause changes to them.
That forces act in pairs that oppose each other.

Teaching / Learning activities
Lesson structure
Prior knowledge
The pupils could draw out a spider diagram (or mind map) summarising what they already know about forces. This will help you to tailor the following lessons appropriately. (10–15 mins)
Main
he pupils should try out the 'Forces at work' practical. The emphasis here is carefully to record observations and measurements (HSW).
Even though forces are invisible, you should try to show them acting. There is no simpler demonstration than showing two magnets repelling or attracting. Many pupils find it difficult to understand that forces *always* act in pairs; there are many situations where the force is not obvious.
Plenary - Always two there are …
Give the pupils a selection of diagrams showing only single force acting at each point. Ask them to add the other 'missing' forces to the diagrams. (5–10 mins)

Teaching suggestions
• **Special needs.** Worksheets and results tables should be provided for each of the stations in the practical task.
• **Extension.** Language is important in the description of forces. Encourage the pupils to find out about and use the words 'tension', 'compression', 'torque', 'couple' and 'moments' whenever possible.
• **Homework.** The pupils should produce charts or graphs of the results of the practical task.

Learning Outcomes
All pupils should be able to measure the effect a force has on an object.
Most pupils should be able to explain how a force can affect the behaviour of an object.
Some pupils should also be able to present the results of an experiment in the appropriate manner.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Equipment and materials required
There are five workstations with small experiments for the pupils to observe. Depending on the class size you may wish to have two of each station type available. **Station 1:** Set of six 50 g masses with holder, thick elastic band (or fishing pole elastic), stand and 30 cm ruler. Mark the elastic in two places, 5 cm apart, using a permanent marker pen so that the pupils have some easy points to measure from. **Station 2:** A stop-watch, a mass holder suspended by string from a stand, a clamp to fix stand to bench, and a set of five 20 g masses. This should act as a simple pendulum. **Station 3:** Set of three 100 g masses, 50 cm ruler, and triangular pivot. The ruler should be balanced on the pivot so that the pupils can place masses on the ruler and balance it. **Station 4:** A synthetic square sponge, ruler, tray and set of eight 50 g masses. **Station 5:** A large wooden block with a forcemeter attached. A range of surfaces (carpet, wood, floor tiles, plastic and possibly glass) that the pupils can drag the block across. The pupils may need some Blu-Tak to keep the surfaces in place. **Station 6:** A large wooden block with a forcemeter attached. An adjustable slope to drag the block up. **Safety.** The pupils should be warned about the hazards of falling masses. Eye protection should be used at stations 1 and 2 in case the elastic or string snaps.

Fusion 1: P2.2 – Measuring Forces

National Curriculum Link up
•3.1b.

Electronic resources: Learning objectives, Practical worksheets, Interactive Drag and drop – Describing forces

Learning Objectives
Pupils should learn:
That forces act between objects and can cause changes to them.
That forces are measured in a unit called the 'newton'.
That forces can be represented by arrows showing the direction, and magnitude, of the force.

Teaching / Learning activities
Lesson structure
Starter - The right tool for the job
Show the pupils a range of measuring instruments and get then to explain what each one measures and how it works. (5–10 mins)
Main
Demonstrate the use of a forcemeter and how to attach objects to it. Then get the pupils to carry out the 'Measuring pushes and pulls' practical task. The emphasis is on measuring the size of the forces carefully and as accurately as possible. The pupils should note down the problems that they have with measuring the sizes of the forces (HSW).
It is important that the pupils gain an understanding of the size of forces in relation to the newton during the practical task. Ask them to estimate, and record, the force they think will be required to lift/move each object before they use the meters. They should then select the appropriate meter for the object. Using the correct meter will also give them more precise measurements. Discuss this after the experiment in relation to How Science Works (see page 158).
The pupils then move on to the idea of representing forces by arrows. This is fairly straightforward, but make sure that they are putting arrowheads on the lines they draw and that the arrows actually point in the right direction.
Plenary - Sentence construction
The pupils must write a set of sentences that includes all of the key words or phrases from this lesson. The fewer sentences needed the better. (5–10 mins)

Teaching suggestions
• **Special needs.** Provide the pupils with a worksheet with a results table for the practical task.
• **Extension.** The pupils can find out how a top-pan balance operates. [Some use springs, but others use the electrical properties of materials.] It is again important the pupils become more familiar with the language of science, so use the terms 'accelerate' and 'decelerate' when possible. With higher attaining pupils you can move on to the effect of forces that are not acting in the same plane. Can they describe what they think will happen if the forces are at right angles?
• **Learning styles.**
Visual: Reading scales off measuring instruments.
Auditory: Describing force diagrams.
Kinaesthetic: Measuring forces practical task.
Interpersonal: Discussing the outcome of the experiment.
Intrapersonal: Evaluating the basic experiments and suggesting improvements.
• **Homework.** The pupils can make a list of all of the devices that can be used to measure forces, and the locations where they are used. They should explain why it is important to measure forces, such as weight, accurately. Examples include electronic bathroom scales, scales at supermarkets, and the electronic balances that are used at the checkouts, weighbridges, and check-in scales at airports and so on.

Learning Outcomes
All pupils should be able to draw arrows to represent the forces acting on an object.
Most pupils should be able to draw a diagram including forces drawn to scale.
Some pupils should also be able to find the resultant force of a set of forces acting on an object.
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Measuring pushes and pulls
Equipment and materials required
A variety of everyday objects that the pupils can weigh: these can be typical laboratory equipment, furniture or pupil equipment. Avoid fragile objects. Pupils will need a range of forcemeters (1 N, 5 N, 10 N, 25 N and so on) and string to attach objects to the meters.
Safety
The pupils should be careful if they are lifting large masses or dragging objects around the laboratory.

Fusion 1: P2.3 – Bending, Stretching

National Curriculum Link up
•3.1b.

Electronic resources: Learning objectives, Practical worksheets, Starter activity – Bending and stretching, Plenary activity – Bending rulers, PowerPoint – Looking for forces, Interactive activity – Describing graphs

Learning Objectives
Pupils should learn:
That weight is caused by the action of gravity on objects.
That a spring will extend evenly when the force on it is increased evenly.
That graphs can be used to find patterns in the behaviour of materials.

Teaching / Learning activities
Lesson structure
Starter - Describing patterns from graphs
Give the pupils a set of graphs that show the results of different experiments, e.g. the distance a projectile travels when fired at different angles, the stopping distance of a car. They have to describe the graphs in as much detail as possible. (HSW). (10–15 mins)
Main
The emphasis of the 'Investigating a spring' practical should be on making accurate and precise measurements. If there is time, you can ask the pupils to record the extension as the spring is unloaded and calculate the mean extension. These results need to be used to plot an accurate line graph (pupils to decide on the appropriate scales and units). The experiment should produce a straight-line graph showing that the extension is proportional to the load; Hooke's Law. The pupils can judge the quality of their experiment by how straight their line is. You can show that all springs behave in this way by showing a set of graphs of extension against load. The steeper the line (higher gradient) the less stiff the spring is. Have more than one set of results on the same set of axes so that you can compare the springs.
Plenary - Bending
Pupils could design an experiment that will compare the flexibility of different types of ruler (the experiment must be able to produce numerical results). (15 mins)

Teaching suggestions
• **Special needs.** Use worksheets with results tables and pre-prepared axes for the graph plotting tasks.
• **Extension.** The pupils can compare the extension of a spring to that of elastic. Springs do not always obey Hooke's Law. Pupils can investigate the limit of the law, the idea of an elastic limit or even the concepts of plastic and elastic behaviour. This can be achieved by stretching thick lengths of plastic such as carrier bags, and noting that it does not return to its original shape.
• **Learning styles**
Visual: Interpreting graphical data.
Kinaesthetic: Measuring the extension of a spring.
Interpersonal: Collaborating with others in practical work.
• **Homework.** The pupils can find out about gravity on other planets. How much would they weigh on each planet? Is there a connection between the strength of gravity and the size (mass) of the planet? Higher attaining pupils may want to take the diameter into account.
• **Functional skills link-up – Mathematics**
Collect and represent discrete and continuous data, using ICT where appropriate. (Level 2)

Learning Outcomes
All pupils should be able to state that the weight of an object is caused by gravity.
Most pupils should be able to describe the connection between the load on a spring and its extension.
Some pupils should also be able to compare the extension of an elastic material to that of a spring.
How Science Works
Recognise that the presentation of experimental results through the routine use of tables … and simple graphs makes it easier to see patterns and trends. (1.2d)
Describe patterns and trends in results … (1.2e)

Additional teachers notes
Comparing weights - Equipment and materials required
A range of objects, including some of very similar weights; sets of masses (50 g, 20 g and 10 g) and holders; forcemeters. **Safety.** If larger objects or masses are used, then warn the pupils about the dangers associated with dropping the materials.
Investigating a spring - Equipment and materials required
A spring, 20 g masses with holder, stand, two clamps and a ruler. For more precise measurements, the pupils will need a pin and some Blu-Tak. The spring should have a low enough spring constant to stretch significantly with a load of 100 g placed on it. **Safety.** The pupils should again be warned about the risks of objects falling on their feet. Wear eye protection in case springs snap.

Fusion 1: P2.4 – Friction

National Curriculum Link up
•3.1b.

Electronic resources: Learning objectives, Practical worksheets, Interactive activity – Friction in sport, Simulation – Friction, Animation – Friction lubrication, SEN activity – Sport and friction, Extension activity – Sport and friction

Learning Objectives
Pupils should learn:
That friction is a force that acts between objects, slowing them or preventing them moving.
That there are a range of factors that affect the frictional forces between objects.

Teaching / Learning activities
Lesson structure
Starter - Get a grip
The pupils make a list of sports/activities where a 'good grip' is essential and explain how this is achieved, for example, putting powder on your hands for weightlifting. The powder absorbs moisture (sweat), which would act as a lubricant. (10 mins)
Main
During the 'Measuring friction' practical task, ensure that the pupils are acting with safety in mind as they move around and drag fairly large masses. Get the pupils to write out a quick risk assessment or to choose the possible risks from a list you have already prepared (HSW: safety).
The results are likely to be quite varied, as pupils tend to pull slightly upwards as they drag; you can discuss this when comparing the results of different groups for the same material and mass combination (HSW: reliability of data).
Now move on to the explanation of frictional forces. Try to move two very flat metal plates across each other; there can be quite high frictional forces. A little oil will make the plates slide much more freely.
Plenary - Rough edges
Show some further electron micrographs (or highly magnified optical micrographs) and ask the pupils to guess what the material or object is. A set of decreasing magnifications is best so that you can 'zoom out'. (5 mins)

Teaching suggestions
• **Special needs.** Provide worksheets with instructions about how to take the measurements. The worksheets should have space for recording results and instructions about how to calculate average values.
• **Extension.** During the 'Measuring friction' experiment the pupils could investigate dragging the objects up an adjustable slope to see if the angle affects the size of the force required.
• **Learning styles**
Auditory: Describing the causes of friction.
Kinaesthetic: Practical work on measuring friction.
Interpersonal: Working in small groups.
Intrapersonal: Understanding how lubricants work.
• **Homework.** The most important device invented to overcome the problems of friction was the wheel. The pupils can find out about how a wheel works and the history of its development or even the (non-serious) attempt to patent the device in Australia in 2001.

Learning Outcomes
All pupils should be able to state that friction is a force that prevents objects moving past each other.
Most pupils should be able to describe the cause of a frictional force in terms of rough surfaces.
Some pupils should also be able to list the factors that affect the magnitude of frictional forces.
How Science Works
Explain how action has been taken to control risk and how methods are adequate for the task. (1.2c)

Additional teachers notes
Equipment and materials required
Per group: a range of forcemeters, a wooden block, three 1 kg masses, a range of surfaces to pull the block across (carpet, tiles, desktop, etc.). **Details.** The two key factors that affect the frictional force are the surface conditions; rougher giving higher friction, and the weight of the object being pulled. They should discover that rougher surfaces produce larger frictional forces and that the heavier the object the greater the force is. **Safety.** The pupils will be moving around the classroom and may be working on the floor. Look out for trip hazards.

Fusion 1: P2.5 – Floating and Sinking

National Curriculum Link up
•3.1b.

Electronic resources: Learning objectives, Practical worksheets, Webquest – Floating and sinking, Plenary activity – Floating and sinking

Learning Objectives
Pupils should learn:
That when an object floats its weight is matched by an equal but opposite upthrust force.
That objects that are more dense than water will sink, while those that are less dense will float.
That when the weight of an object is greater than the upthrust force it will sink.

Teaching / Learning activities
Lesson structure
Starter - Under pressure
Use mini-whiteboards to hold a quickfire quiz about forces. The pupils keep their own score and the person that reaches ten points first is the winner. This could also be played as a team game. (10 mins)
Main
The 'Measuring upthrust' practical is a fairly simple one, but it can be a bit messy. Make sure that the pupils are recording the *change* in the forcemeter reading. The pupils should take simple safety precautions and look out for ways of improving the basic method (HSW: evaluation). Try to get the pupils to see if there is any connection between the size of the upthrust and the shape of the object. This idea can later be linked to the shape of boats. Explaining upthrust for an object that is submerged is rather difficult. Make sure that the pupils understand that there are forces (pressure) all around the object. Then they need to be guided to an understanding that the forces on the bottom of the object are larger that the forces on the top and that this produces an overall upwards force.
Plenary - Cartesian diver
Place an inverted pen top into a large plastic bottle full of water and seal it. The top should have a small bubble of air in it. Squeeze the bottle and the pen top should sink. Can the pupils explain what is happening? [Squeezing the bottle causes the pressure in the bubble to increase and so its volume decreases. This makes it denser so it sinks.] (5–10 mins)

Teaching suggestions
• **Special needs.** Provide a worksheet with a table to help these pupils organise and process their results for the 'Measuring upthrust' activity. Some pupils may need additional help with attaching the objects to the forcemeter.
• **Extension.** The pupils can look into how airships or hot air balloons work. You can demonstrate the lift of a small hydrogen balloon (buy a helium one from a shop) by attaching it to a forcemeter. The pupils have to consider the expansion of air in the hot air balloon in terms of particle behaviour.
• **Learning styles**
Visual: Observing the behaviour of floating objects.
Kinaesthetic: Measuring upthrust.
Interpersonal: Discussing the cause of upthrust.
Intrapersonal: Answering questions in the 'Under pressure' starter quiz.
• **Homework.** The pupils could build their own Cartesian diver at home as mentioned in the plenary.
• **Functional skills link-up – Mathematics**
… Subtract whole numbers using a range of mental methods (Level 1). (See 'Measuring upthrust'.)

Learning Outcomes
All pupils should be able to draw a diagram showing the forces acting on a floating object.
Most pupils should be able to use the idea of balanced forces to explain why some objects fl oat while others do not.
Some pupils should also be able to describe how the forces change on a floating object as it is loaded up and eventually sinks.
How Science Works
Describe and suggest how … implementation could be improved. (1.2e)
Explain how action has been taken to control risk … (1.2c)

Additional teachers notes
Equipment and materials required
Per group: A range of forcemeters, a range of objects denser than water (various metal blocks, glass, etc.) and a wooden object less dense than water.
Details
The objects will have to have string loops tied around them in order for them to be attached to the forcemeter. Once the pupils have tested all of the objects that sink, get them to calculate the upthrust on the object that floats. The forcemeter should read zero when the object is floating. This means that the upthrust and weight are equal so proving the point from earlier in the lesson. **Safety.** Watch out for spilled water hazards.

Fusion 1: P2.6 – A Matter of Density

National Curriculum Link up
•3.1b.

Electronic resources: Learning objectives, Practical worksheets, Interactive Drag and drop – Density calculations, Homework activities A and B – Floating key words

Learning Objectives
Pupils should learn:
That the mass of an object represents the amount of material (matter) it contains.
That the volume of an object is the amount of space it occupies.
That graphs can be used to find patterns in the properties of materials.

Teaching / Learning activities
Lesson structure
Starter - Accident at work?
Spray-paint a block of expanded polystyrene to look like a brick, wooden block or chunk of metal. Carry it convincingly in a tray, trip and drop it on your foot. The pupils have to explain why it didn't hurt. (5 mins)
Main
The pupils will be required to perform some calculations of density; many will not be entirely confident with calculations. Go through a few examples before moving on to the practical task.
The practical task 'Measuring density' is fairly straightforward, but can have a number of inaccuracies due to the measurement of volume. At the end, the pupils could discuss the problems with accuracy in measuring the volume and share the results for each material to get an average value (HSW: improving the reliability of data).
Some sample materials will not sink in water. You can deliberately use these in the practical task in order to lead to a discussion about how their volume can be measured so that their density can be found.
To summarise the results, place a series of material samples in order of density so that the pupils can check their results. You can add additional materials to the row.
Plenary - Boat building
Give each group of pupils a sheet of aluminium foil, measuring approximately 20 cm by 20 cm. They have five minutes to build a boat capable of floating and supporting as many 20 g masses as possible. After the time is up, test the boats to destruction. (15 mins)

Teaching suggestions
• **Special needs.** The pupils should be provided with a template for the calculations of density so that they learn how to lay out these calculations clearly.
• **Extension.** These pupils can look into the density of gases (make sure that they do not think that gases are mass/weightless). Show the pupils a hydrogen-filled balloon and a carbon dioxide-filled one and ask them to explain their behaviour. They could discuss the strange behaviour of water as mentioned in 'Did you know?'
• **Learning styles.**
Visual: Taking measurements using a forcemeter.
Kinaesthetic: Building boats.
Intrapersonal: Understanding the difference between weight and density.
Interpersonal: Working in groups to measure density.
• **Functional skills link-up – Mathematics**
Carry out calculations with numbers of any size in practical contexts. (Level 2) See 'Measuring density'.
• **Homework.** The pupils can research the design of ships to find out how they are made to fl oat. They can also find an explanation of why submarines can fl oat and sink at will.

Learning Outcomes
All pupils should be able to compare materials in terms of density.
Most pupils should be able to decide if a material will float based on the density.
Some pupils should also be able to measure the density of substances in grams per centimetre cubed (g/cm^3).
How Science Works
Describe and record observations and evidence systematically. (1.2d)

Additional teachers notes
Equipment and materials required
Per group: a range of forcemeters, measuring cylinders large enough to fit the samples into or displacement cans with measuring cylinders. A range of sample materials; these do not need to be regularly shaped but they do need to be denser than water so that they sink. Suitable materials include metal blocks, plastics, ceramics and various rocks. Top-pan balances if available.
Safety
Watch out for water spillage and dropping samples onto feet.

Fusion 1: P2.7 – Fuels Alight

National Curriculum Link up
•3.1a.

Electronic resources: Learning objectives, Practical worksheets, Interactive Drag and drop – Burning fueals and their uses, PowerPoint – Energy changes, Starter activity – Fuels alight, Starter activity – The fire triangle

Learning Objectives
Pupils should learn:
That fuels are substances that are burned to release useful energy.
That different fuels release different amounts of useful energy when they are burned.

Teaching / Learning activities
Lesson structure
Starter - Fuel for a fire
The pupils should give their own definition of a fuel. They should also make a list of all the fuels they know and give an example of how, or where, the fuel is used. (5–10 mins)
Main
Demonstrate the combustion of small samples of charcoal, wood (on a heat-resistant mat) and gas (a Bunsen) to show that they all burn in a similar way: releasing light and heat energy.
The pupils will enjoy the practical task 'Comparing fuels'. The task presents some new hazards, so there is a good opportunity for the pupils to carry out a risk assessment (HSW: safety). The comparison of the different fuels will not lead to an accurate measurement of how much energy is released but the pupils can move on to look at some of the problems associated with the measurements, such as energy loss to the surroundings (HSW: evaluation). If they have time, the pupils should use a bar chart to show their results. They should be able to explain why a bar chart is the best way of representing this information (HSW: presenting data). After the experiment, ask the pupils to list ways that they could improve the practical to be more accurate.
Plenary - Tiger, tiger, burning bright
The pupils can write a short poem about fuels and combustion. It can be judged on scientific accuracy or aesthetic beauty. (10–15 mins)

Teaching suggestions
• **Special needs.** A clear step-by-step method should be provided for the practical task so that the pupils can concentrate on taking accurate measurements of changes in temperature.
• **Extension.** Pupils could make, and carry out, a plan to measure the amount of energy released by the consumption of equal masses of a sample fuel. This would involve measuring the mass of the spirit burner before and after the experiment and calculating the amount of energy released (temperature rise in the water) per gram of fuel used (HSW: controlling variables).
• **Learning styles**
Visual: Watching combustion processes.
Auditory: Reading out poems.
Kinaesthetic: Carrying out the comparison of different fuels.
Intrapersonal: Evaluating experimental procedures.
Interpersonal: Working in groups.
• **Homework.** When fuels burn without enough oxygen, the gas carbon monoxide is formed. The pupils can find out why this is a very dangerous gas and how it can be detected.
• **Functional skills link-up – Mathematics**
Collect and represent discrete and continuous data, using ICT where appropriate. (Level 2) See 'Comparing fuels'.

Learning Outcomes
All pupils should be able to state that a fuel is a substance that releases heat, light and sometimes sound when burned.
Most pupils should be able to explain that different fuels release different amounts of energy when burned.
Some pupils should also be able to describe the products of combustion.
How Science Works
Describe and suggest how planning and implementation could be improved. (1.2e)

Additional teachers notes
Equipment and materials required
Per group: two spirit burners labelled A and B, boiling tubes, a 10 cm3 measuring cylinder, a thermometer (0.5°C is best), a retort stand and a stop clock. Fuel A is ethanol and fuel B is paraffin. The fuels should be soaked into cotton wool inside the burners to reduce the chance of spillage. **Safety.** Eye protection must be worn. Pupils to tie back hair and clothing. The pupils will be using only very small quantities of fuels for the practical, but they must be warned about the risk of spillage and combustion. Spirit burners must not be moved while they are lit. Ethanol is highly flammable and harmful: CLEAPSS Hazcard 40A. Paraffin is harmful: CLEAPSS Hazcard 45B.

Fusion 1: P2.8 – Burning the Past, Wrecking the Future?

National Curriculum Link up
•3.1a. 3.4c.

Electronic resources: Learning objectives, Practical worksheets, Animation – Fossil Fuels, Plenary activity – Burning the past, wrecking the future, Homework activities A and B – Fossil fuel information, Webquest - Carbon footprints

Learning Objectives
Pupils should learn:
That fossil fuels are the remains
of plants and animals that lived millions of years ago.
That fossil fuels are an important energy resource and are used in the production of electricity and for transport.
That burning fossil fuels has environmental consequences.

Teaching / Learning activities
Lesson structure
Starter - Old fossil
Show the pupils slides of fossils (or the real thing) and ask them what they think they are and where they come from. (5–10 mins)
Main
Have some samples of fossil fuels available for the pupils to see, as many will not be familiar with them. A rough lump of coal, a sealed container of crude oil and a squirt of gas from a gas tap should be sufficient. If you have a set of samples of the fractions made from oil, you can point out the petrol and diesel fuels to show how oil is used in cars too.
The idea of a carbon footprint is quite a tricky one. Explain that the more fuels you use the bigger your effect on the atmosphere; then move onto the 'carbon footprint' task. This involves making judgements about personal fuel use, if pupils can't make estimates then provide examples on a worksheet (HSW: issues). Pupils will need support to help them to make their estimates and perform the calculations from the worksheets. Most will require calculators.
Plenary - Smaller carbon feet
The pupils must list a set of steps that they could take to reduce their carbon footprint. These should be ways to reduce fuel use and to use the fuel more efficiently. The suggestions could be written on cut-out footprints and added to a display board. (10 mins)

Teaching suggestions
• **Special needs.** The carbon footprint task can be quite complex. The pupils should be led through a few examples before completing their own assessment; this should be based on some multiple choice questions such as what type of house they live in, what type of holiday they take, how they travel to school and so on.
• **Extension.** The pupils could find out about peat. This was once a very popular form of fuel but now its use is very restricted.
• **Learning styles**
Auditory: Talking about dinosaurs and the formation of fossil fuels.
Interpersonal: Discussing their personal impact on the environment.
Intrapersonal: Evaluating a carbon footprint.
• **Homework.** Where do our fossil fuels come from and how long will supplies last? The pupils can find out information about the sources of the fuels used in our power stations, homes and cars and look at the latest estimates of how long these supplies will be available.
• **Functional skills link-up – Mathematics**
Carry out calculations with numbers of any size in practical contexts. (Level 2) See carbon footprint calculation.

Learning Outcomes
All pupils will be able to state where fossil fuels come from and that they are a non-renewable resource.
Most pupils will be able to describe the steps in the formation of fossils fuels.
Some pupils will also be able to describe the link between the use of fossil fuels and global warming.
How Science Works
Describe some benefits and drawbacks of scientific developments with which they are familiar. (1.1b)

Additional teachers notes
Equipment and materials required
The pupils need access to worksheets containing information about carbon footprints and a calculator. The worksheet should contain step-by-step instructions.
Details
To calculate their carbon footprint, the pupils will have to know some of the details of their lifestyles. Provide two sample details (one with a high carbon footprint and one with a low footprint) for the pupils to analyse if they are unclear of their own details. Pupils will be required to multiply and add to get their total footprint.

Fusion 1: P2.9 – Renewables – Cleaning up our Act

National Curriculum Link up
•3.1a. 3.4c.

Electronic resources: Learning objectives, Practical worksheets, Interactive Drag and drop – Renewable sources of energy, Starter activity – Cleaning up our act

Learning Objectives
Pupils should learn:
There are a range of renewable energy resources that can be used to produce electricity.
That to maintain a reliable electricity supply and range of
different resources, renewable and non-renewable are needed.

Teaching / Learning activities
Lesson structure
Starter - Biofuels at work
Show the pupils a video clip showing how biofuels are produced and used. Willow is an important one in the UK and it is easy to understand, as the willow is simply burned. (10–15 mins).
Main
Growing biofuels takes quite a lot of land; you may want to discuss whether the land would be better used to grow food crops (HSW: issues). Pupils may have difficulty understanding that biofuels are renewable because they 'disappear' when burnt. It's all a matter of being able to get more; remind them how long it takes for coal to form and point out that a crop can be grown every year.
The pupils can look at some of the ways of producing electricity with the 'Testing renewable energy' practical tasks. Ask them to try to describe the energy transfers that are happening using correct scientific language. They should also take note of the limitations of the technology; will this work in all areas and in all conditions?
Plenary - How green is your power?
Give the pupils some advertisements from energy companies, producers and distributors. They have to discuss and decide which company is the 'greenest'. (10 mins)

Teaching suggestions
• **Special needs.** Provide explanations of how the electricity generating devices operate. The pupils can then answer a set of questions about each process leading them to realise the limitations of each of the methods.
• **Extension.** Why don't biofuels contribute to the greenhouse effect even though they are burned? Get the pupils to look into this; they need to find out that the carbon is taken back out of the atmosphere when the plants photosynthesise. They might find that growing crops does have some effect because of the production processes.
• **Learning styles**
Visual: Observing energy transfers in different resources.
Auditory: Discussing what makes a resource renewable.
Kinaesthetic: Exploring energy resource models.
Interpersonal: Discussing the 'greenness' of energy companies.
Intrapersonal: Reflecting on the challenge of changing our energy sources.
• **Homework.** The pupils can produce a booklet trying to persuade people to use renewable energy resources instead of fossil fuels.
• **Functional skills link-up – English**
Present information/points of view clearly and in an appropriate form. (Level 1) Discussing biofuels.

Learning Outcomes
All pupils will be able to name several renewable energy resources.
Most pupils will be able to describe the advantages and disadvantages of different resources.
Some pupils will also be able to produce a balanced opinion of the need for different resources.
How Science Works
Recognise that decisions about the use and application of science and technology are influenced by society and individuals. (1.1b)

Additional teachers notes
Equipment and materials required
The pupils will be visiting stations showing how electricity can be generated. If there is enough equipment, two of each station should be set up. **Station 1:** Solar power – A solar panel connected to a low power bulb or small motor. A bright lamp if there is no direct sunlight available. **Station 2:** Water power – A water turbine connected up to the tap. Ideally the turbine should be enclosed and the water should drain out into the sink. **Station 3:** Wind power – A wind turbine connected to a low power lamp or motor. A hairdryer (set on low temperature) to spin the turbine. **Station 4:** 'Animal' power – A wind-up radio or torch. A hand-powered turbine connected to a low power lamp or motor would work as an alternative. **Safety.** Make sure that the hairdryer isn't used on a hot setting as this can cause burns. Make sure it is safety tested.

Fusion 1: P2.10 – Making More of Energy

National Curriculum Link up
•3.1a

Electronic resources: Learning objectives, Practical worksheets, Interactive Drag and drop – Heat energy transfers, Animation – Global warming, Simulation – Hot house

Learning Objectives
Pupils should learn:
That the amount of energy we use can be reduced by taking measures to prevent heat loss.
About the environmental costs of wasting energy.

Teaching / Learning activities
Lesson structure
Starter - My best suit
The pupils have to write an outline plan that can be used to test which clothing material is the best at keeping you warm. (10–15 mins)
Main
Show the pupils some of the materials typically used for insulation. This can be clothing or even some materials used in buildings. You should be able to get hold of some foil-backed foam as used in the cavities between brick layers. **Safety:** fibreglass materials need to be handled with gloves, and wear eye protection.
Allow students to complete the 'Keeping heat in' practical. The pupils insulate two of the boiling tubes in different ways with the materials provided, while leaving one un-insulated. They can use tape or elastic bands to hold the material in place. Once this is done, the tubes will not fit in normal racks so the pupils stand them in the beakers. They pour hot water into one of the tubes, insert the thermometer, wait for the water to reach 70°C (or 60°C) and then measure how much the temperature falls over a five-minute period. They then repeat the procedure with the other two tubes to compare the effectiveness of the insulation. Some pupils may want to make aluminium lids to prevent energy escaping through the top of the tubes.
Plenary - Pile up the savings
Give the pupils a table of house insulation measures and the savings that they will make each year. The pupils have to decide which measures they would take and in what order. (5–10 mins)

Teaching suggestions
• **Special needs.** For the 'Keeping heat in' practical have some boiling tubes pre-insulated to save time. The pupils can then concentrate on recording the cooling of the tubes more carefully. If data-logging equipment is used, then the pupils can spend more time looking at the trends in the data during and after the experiment.
• **Extension.** Consider the 'Keeping heat in (alternative)' practical. This can lead to discussions about the ability of different materials to store different amounts of thermal energy. Water is a particularly interesting substance when it comes to specific heat capacity. You may want the pupils to plot cooling curves. This can lead to the idea that the amount of cooling depends on the temperature difference between the object and the surroundings.
• **Learning styles**
Visual: Recording thermometer readings.
Auditory: Discussing how thermal energy movement is controlled.
Kinaesthetic: Carrying out investigations into heat loss.
Interpersonal: Discussing the variables associated with cooling.
Intrapersonal: Considering fair tests.
• **Functional skills link-up – Mathematics**
Carry out calculations with numbers of any size in practical contexts. (Level 2) Analysing figures for savings made from home insulation measures.
• **Homework.** The pupils can bring in labels from food products to be used in the next lesson. Make sure that they know that they will need a large variety of labels.

Learning Outcomes
All pupils will be able to list measures that can be taken to reduce energy loss. *Most pupils will be able to* describe a simple method to test energy saving techniques.
Some pupils will also be able to describe the consequences of inefficient use of energy resources in terms of environmental impact and monetary cost.
How Science Works
Describe an appropriate approach to answer a scientific question using a limited range of information and making relevant observations and measurements. (1.2a)

Additional teachers notes
Equipment and materials required
Per group: three boiling tubes, three 100 cm^3 beakers, thermometers, a stop-clock, aluminium foil, a range of insulating materials (cotton wool, thin layers of foam, etc.) and some sticky tape, kettles or another source of hot water. Optional: data-logging equipment with temperature sensors.
Safety
The pupils will be handling hot water; they must not attempt to hold the boiling tubes while pouring water directly from a kettle into them.

Fusion 1: P2.11 – How Much Energy?

National Curriculum Link up
•3.1a.

Electronic resources: Learning objectives, Practical worksheets, Homework activities A and B – Forces and energy crossword

Learning Objectives
Pupils should learn:
That energy can be measured in a unit called the joule.
Larger amounts of energy are measured in kilojoules.
The amount of energy released by a food can be estimated by burning it, transferring the energy to water and measuring the temperature increase of the water.

Teaching / Learning activities
Lesson structure
Starter - Fast food sort
Give the pupils a set of about ten different food labels. Ask them to sort the labels quickly into various orders while you give a one-minute countdown for each sort. Sorting orders should include fat content, salt content, sugar content and finally energy content. (10 mins)
Main
Pupils should be reminded that it is simplistic to judge a food on energy content alone. Take some time to mention the other values, e.g. salt levels, protein, carbohydrates and vitamins, and their importance. You can briefly discuss what the energy is used for in the body [carrying out chemical reactions] and where it ends up [as heat].
The 'Burning food' practical task does not give very reliable results, but it does give a general indication about which foods types have most energy. Pupils need to link this to the idea that foods with high fat or sugar content have a larger supply of energy. The pupils should also be thinking about the limitations of the experiment. Are they using equal masses of food, did they hold the sample the same distance beneath the tube, is all of the energy going into the water, and so on (HSW: controlling variables, evaluation).
Food technologists have to be very careful not to let any of the energy of the food escape without being measured.
Plenary - Food 'Top Trumps'
The pupils can play Top Trumps with the food labels (which has the highest fat?, etc.). The winner is the first to win all of the labels. (10 mins)

Teaching suggestions
• **Special needs.** It is important that the pupils evaluate the limitations of the experiments. Use a question and answer session to lead the pupils to a realisation of the limitations of the measurements that they made, so that they can produce a suitable set of improvements.
• **Extension.** The pupils can find out more details about photosynthesis. What else, besides energy from sunlight, do plants need and what do they produce beside food?
• **Learning styles**
Visual: Taking temperature measurements.
Auditory: Discussing the improvements that can be made to the experiment.
Kinaesthetic: Sorting cards against the clock.
Interpersonal: Working in teams to test food samples.
Intrapersonal: Interpreting the results of an experiment.
• **Functional skills link-up – Mathematics**
Collect and represent discrete and continuous data, using ICT where appropriate. (Level 2) See 'Burning food'
• **Homework.** The pupils can find out about the energy requirements of different groups of people, including athletes. How much energy do they require each day?

Learning Outcomes
All pupils will be able to describe a simple method for measuring the energy that can be released by burning food samples.
Most pupils will be able to carry out a procedure to estimate the energy content of a food sample.
Some pupils will also be able to evaluate and improve on the simple procedure.
How Science Works
Recognise the range of variables involved in an investigation and decide which to control. (1.2b)
Describe and suggest how planning and implementation could be improved. (1.2e)

Additional teachers notes
Equipment and materials required
Per group: Bunsen burner, tongs, (or a metal spike), thermometer, boiling tube, retort stand with clamp and access to food samples.
Safety
Eye protection must be worn. Some pupils may be allergic to peanuts or other nuts so do not use them. Check that there are no other food allergies.


FUSION