Fusion 3: P2.1 – Forces and Motion

National Curriculum Link up

•1.1a, b; 2.1a, b and c; 3.1b

Learning Objectives

Pupils should learn:

That the movement of an object can be described in a range of ways including scientifically.

That the shape of an object affects the way it falls through the air.

Teaching / Learning activities

Lesson structure

Starter – Quick off the marks

Before the pupils open their textbooks, ask them to draw a cartoon of somebody moving quickly. Can they draw a picture of somebody moving very slowly? Ask: 'Why is easier to give the impression of rapid movement than slow movement?' (5–10 mins)

Main

In this fi nal physics topic, the pupils investigate ideas about motion, forces and pressure. This often involves mathematical expressions, an area where a number of pupils have difficulties. These relationships are fairly simple ones, but sometimes the pupils get confused about the terms used, so it is important to guide them through the calculations carefully explaining each step. Pupils will also have to adjust to using scientific units, something they may not think about much in mathematics. Some pupils will need to consider the rearrangement of the equations too.

This spread revises some of the concepts the pupils encountered in Fusion Book 1; use it to extract pupils' ideas about movement to inform your teaching of the rest of the topic. Use the task a) to see how the pupils can describe movements; they should be able to give an impression of speed, direction and perhaps even forces and acceleration.

One thing that you could discuss is the parachute invented by Fauste Veranzio. Do the pupils think that he came up with the idea and then just jumped off the tallest thing he could find to see if it worked? How would he go about developing the parachute and improving it until it was good enough to work for a human? Perhaps they could think of the stages involved in this process.

To come up with this invention must have taken quite a leap of imagination. Do the pupils think that it was designed for a particular reason? Could it be that there were a large number of fires in Venice or even earthquakes? Did Fauste become famous, or did people think he was just plain 'nuts'. It was nearly two hundred years later that Jacques and Joseph Montgolfier invented the hot air balloon and gave people something really challenging to jump from.

_ The practical activity 'Faster, slower' is relatively straightforward; focus on the problems of accurate measurement (How Science Works; reliability and precision).

Plenary - Falling on the Moon

Show the video clip demonstrating how a hammer and feather fall when released on the Moon. Can the pupils explain what is happening? (5–10 mins)

Teaching suggestions

• **Extension.** The pupils can extend the 'faster, slower' activity so that the object has to fall vertically as well as slowly.

• **Learning styles.**

Visual: Designing an advertisement poster.

Auditory: Discussing the development of parachutes.

Kinaesthetic: Carrying out dropping experiments.

Interpersonal: Group work.

Intrapersonal: Thinking about the development of parachutes.

• **Homework.** Allow the pupils to look into the history of the parachute from its early origins up to the highly efficient designs of the 21st century. There are quite a lot of people involved from a wide range of cultures and nationalities. Alternatively, pupils could look at ballooning, hang gliding or even powered flight.

Learning Outcomes

All pupils should be able to identify rapidly moving objects.

Most pupils should be able to describe an experiment to find out which shape of object falls through air most easily.

Some pupils should also be able to describe the difficulties involved in measuring time.

Additional teachers notes

Equipment and materials required

A4 paper, meter rule, scissors.

Safety

Pupils must not stand on unstable objects to increase the fall distance.

Fusion 3: P2.2 – Measuring speed

National Curriculum Link up

•3.1b

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: That average speed can be calculated by measuring the distance an object covers in a set period of time. How to use the equation 'average speed = distance ÷ time' to calculate the speed of an object. What we mean by precision in timings.	**Lesson structure** **Starter - Quick estimates** Ask the pupils to make a list of six moving objects and estimate their speeds. They should put the list into order from the fastest to the slowest. Use their ideas to discuss what is needed to work out speed (distances and times), the units that speed can be measured in and to give them some insight into how fast some objects actually move. (10–15 mins) **Main** Most pupils will be vaguely aware of measuring speed; this will often be in miles per hour (mph) as opposed to a more appropriate unit. During the 'quick estimates' starter many pupils will probably make estimates in this unit. Tell them that this unit is not commonly used in scientific measurement in a laboratory, even though is used for road travel. They will probably want to know a conversion factor (1 mph = 1.61 km/h = 0.45 m/s). Some of the pupils will need support with the calculations, even though they are relatively simple. Encourage them to lay out the calculations as clearly and formally as possible so that they get into a routine; this will help them to learn the equation and ensure that they reach the correct answer. Some will not be comfortable with the way division is laid out here; you can use the ÷ symbol as an alternative. The pupils can now carry out the **'Speed check'** practical task. Focus on the need to repeat measurements, as there will be quite a bit of variation between runs. Use this to discuss the reliability of the data (How Science Works). The pupils should use an average time to calculate the average speed. During the experiment they should notice the problems with starting and stopping the stopwatch (e.g. reaction times). Discuss this problem at the end of the practical; the pupils will come up with the idea that electronic timing would give more accurate results; a proposition they should be testing in the next lesson. There is no point in using a stopwatch that measures to the nearest one-hundredth of a second if reaction times are, at best, one-tenth of a second. The early records mentioned in Summary question 3 can be used to get over the ideas of increasing precision being linked with newer, automatic, timing systems. **Plenary - Reaction time** Can the pupils come up with a reliable method of measuring somebody's reaction time? They need to ensure that they are measuring the genuine reaction time, so the subject can't be anticipating when the clock is started or stopped. (10–15 mins)	• **Special needs.** The experimental equipment can be set up in advance by your technicians with appropriate distances marked out with tape or erasable marker. This allows the pupils to focus on timing and reliability. • **Extension.** How accurately do the pupils think that the 100 metre track or the 50 metre swimming pools are constructed? If the pool expanded a bit when it was filled with water, would this matter for world records? • **Learning styles** **Visual:** Observing the motion of objects along tracks. **Auditory:** Discussing precision in measurements. **Kinaesthetic:** Experimental task. **Intrapersonal:** Thinking about the limitations of measurements. **Interpersonal:** Collaborating in group work. • **Homework.** What is the pupil's average speed when travelling home? They can use a local map to estimate the distance and time of their journey. Compare the results in a range of ways during next lesson.

Learning Outcomes	Additional teachers notes
All pupils should be able to calculate the speed of an object using the equation. *Most pupils should be able to* describe an experiment that can be used to measure the average speed of an object. *Some pupils should also be able to* make judgements about the precision required in a speed measurement. **How Science Works** Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	**Equipment and materials required** Per group: toy car or dynamics trolley, cardboard box to catch car, stopwatch, a long adjustable slope, blocks or retort stands to support slope, tape measure or metre rule. **Safety** Avoid objects falling to the floor. Use foam or a box to stop the car.

Fusion 3: P2.3 – Going electronic

National Curriculum Link up
•3.1b

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: Those different sensors can be used to measure the speed of an object. Electronic sensors are more accurate and precise than stopwatches. How to check the reliability of measurements.	**Lesson structure** **Starter - Choosing the right instrument** Show the pupils a range of measuring instruments with different precisions and ranges and a list of tasks that could be done with them. For example, large and small measuring cylinders, thermometers with different scales, normal clock and stopwatches, different rulers and so on. The pupils must match the instruments to the jobs and explain their choices. (10–15 mins) **Main** Speed cameras are always going to be controversial and you can discuss their social implication during the lesson. Many pupils will think that *all* speed cameras use 'radar' to measure the speed of a moving car. Point out that there are a range of methods that can be used, some which are similar to the experiments you will be carrying out during the lesson. As you are describing the operation of the speed camera in the pupil book, you can show the equipment that will be used during the practical task and compare it. The pupils should grasp the idea that the equipment is merely measuring the time it takes to move between two points, a fixed distance apart, and calculating speed from this. Sensors are available that measure speed using ultrasound pulses. These can be used as alternative equipment for some of the practical tasks during this lesson. Use the manual that comes with the sensors to find out how to set them up. The pupils can now carry out the **'Speed check'** activity. It may be necessary for only a few groups to do this at a time, depending on how limited your equipment is. A worksheet based around speed calculations, or similar, can be used to occupy other groups until their turn. Using and understanding how the equipment works can be quite demanding at first, but success will demonstrate the pupils' ability to measure precisely using quite advanced techniques. During the practical, the pupils need to understand that they will not get a precise speed measurement unless both the time and distance are measured precisely. They should measure the separation of the light gates in millimetres if possible. Repeat readings to calculate an average should be used again (How Science Works). From the results of the experiment, the pupils should notice that the car is getting faster the further down the slope it is and that the car slows when moving along the bench. You should ask them to link this to the idea of forces acting on the car using some force diagrams. They will study this idea in more depth during lesson P2.5. **Plenary - Watching from on high** It has been suggested that all cars should be linked to a satellite tracking system so that their road-use can be monitored. This would allow the government to charge road tax based on how much, and at what times you use the road. It would allow speed checks too. The pupils should put forward some arguments for and against this system. (10–15 mins)	• **Special needs.** The experimental equipment can be set up in advance by your technician and the light gates set at appropriate distances. • **Extension.** With some pupils you can look at the concept of acceleration using the different speed measurements along the ramp. • **Learning styles** **Visual:** Watching demonstration about speed cameras. **Auditory:** Discussing the usefulness and fairness of speed cameras. **Kinaesthetic:** Measurement of distances and times. **Intrapersonal:** Thinking about the social implications of being monitored. **Interpersonal:** Debating the fairness of speed cameras. • **Homework.** Do speed cameras save lives or are they just designed to make money? The pupils can prepare a brief report on this topic.

Learning Outcomes	Additional teachers notes
All pupils should be able to measure the speed of an object using a sensor. *Most pupils should be able to* describe how to make precise and reliable measurements of the speed of a moving object. *Some pupils should also be able to* obtain reliable data, including making systematic observations and measurements with precision, using a range of apparatus. **How Science Works** Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	**Equipment and materials required.** Per group: toy car or dynamics trolley, piece of foam or cardboard box, an adjustable slope, some stiff card and Blu-tak, tape measure or metre rule. They will also need a pair of light gates connected to a timer or data-logger and some stands to hold the light gates in place. The cars will need stiff card fins mounted on top of them to break the light beam. **Safety.** Avoid falling objects. Use foam or a box to stop the car.

Fusion 3: P2.4 – Going steady

National Curriculum Link up

•3.1b

Learning Objectives

Pupils should learn:

That the motion of an object can be represented graphically.

How to interpret distance–time graphs.

Teaching / Learning activities

Lesson structure

Starter - Understanding graphs

Show the pupils some simple line graphs and ask them what the parts of the graph are called. Can they describe the patterns that the graphs are showing? Make sure that they are actually describing what the information shows and not just the shape of the line on the graph. (5–10 mins)

Main

This lesson introduces the graphical representation of motion. Only distance–time graphs are covered here, but a large number of lower attaining pupils struggle to
interpret graphs correctly. They will often say things like 'the *line* goes up' or 'the *line* stays straight' instead of describing the relationship shown. Use the lesson to get the pupils to practise their descriptions of relationships between variables (How Science Works).

Take time with the horizontal and vertical axis descriptions of the first graph; point out that during each hour the distance covered is the same so the car must be travelling at a steady speed. This gives a straight line sloping upwards on the graph.

When you move onto the more complex graph in the 'Different speeds' section you should break down and explain each part of the motion separately.

The pupils now move on to analysing the graphs numerically; taking distance and time values to calculate the speed. Depending on the groups you might want to challenge them to find the speed during different parts of the motion of an object from a graph. It is important that they understand that they need to use the amount that the distance has changed (not the total distance so far) and the amount that the time has changed to calculate the speed during a particular section. Watch out for pupils being unable to calculate the speed during sections where the distance has not changed at all (when the object is stationary); they may become confused when trying to divide zero by something.

In this final part of the lesson you can discuss the slope in more detail. The steeper the line (you might want to use the term 'gradient' with higher attaining pupils) the faster the object is moving. If you asked the pupils to calculate the speed of an object during different parts of its motion then this will be fairly obvious to them. Conclude with a bit more graphical analysis or by developing the pupils graph plotting skills.

Plenary - The journey

Show the pupils a range of distance–time graphs and ask them to describe, in detail, what they show. (5–10 mins)

Teaching suggestions

• **Special needs.** Provide some print-outs of graphs so that the pupils can add on descriptions of the motion next to the relevant parts of the graph.

• **Extension.** The pupils should consider distance–time graphs that are showing some acceleration.

• **Learning styles**

Visual: Interpreting graphs.

Auditory: Describing the motion of an object.

Kinaesthetic: Drawing or sketching graphs.

Intrapersonal: Understanding how a graph can describe the movement of a real object.

Interpersonal: Discussing the meaning of parts of a graph in groups.

• **Homework.** During the next lesson the pupils will be preparing a presentation about forces and sport; they can find suitable material to bring in for this lesson.

Learning Outcomes

All pupils should be able to use a distance–time graph to identify when an object is moving or not moving.

Most pupils should be able to describe the motion of an object by interpreting a distance–time graph including a comparison of the speed during different sections of the journey.

Some pupils should also be able to calculate the speed of an object using information read from a distance–time graph.

How Science Works

Explain how the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends. (1.2d)

Additional teachers notes

Equipment and materials required

Squared paper or graph paper.

<table>
<tr><td colspan="4">Fusion 3: P2.5 – Changing speed, changing direction</td></tr>
<tr><td colspan="4">National Curriculum Link up
•3.1b</td></tr>
<tr>
<td>Learning Objectives
Pupils should learn:
That unbalanced forces cause an object to accelerate; this can be a change in speed or direction.

That balanced forces have no effect on the motion of an object.</td>
<td colspan="2">Teaching / Learning activities
Lesson structure
Starter - Forces and their effects
Ask the pupils to summarise what they already know about forces and their effects, specifically they should focus on how the forces affect the movement of an object. Use this information to check for misconceptions that still remain about forces. (10–15 mins)
Main
Some pupils will already know that the correct term for speeding up is ‘accelerating’. They need to link acceleration to unbalanced forces acting on an object. The forces are not always obvious to pupils, so use force diagrams whenever you can.
You should be able to find a video clip of an ice speed-skating race. During this you can pause and point out the starting positions; the skates are turned at right angles to increase friction. When the skater is skating the blades are pointed in the direction of travel to reduce friction. You can take the opportunity to point out the exotic shapes of the costumes; the idea of streamlining will be covered more next lesson.
The pupils can now complete the ‘Forces and sports’ task, where they make a presentation about how forces are used in sport to change the movement of objects. This can be completed on computers with a presentation package or could be a paper-based task where posters are produced. The pupils can work individually or in small groups. At the end you can ask some pupils to report their ideas back to the class.
Move on to the different effects that balanced and unbalanced forces have on objects, then get the pupils to give accurate descriptions of what the forces are doing. It can be difficult to get the pupils to accept that an object can still be moving even though the forces on it are balanced. An example that can be used is a car moving at constant speed, the engine force is needed to balance the drag and the car would slow down if the engine was switched off. You can revisit this point during the next lesson when describing terminal velocity during parachute jumps.
Plenary - Motorway
Why are motorway entrance ramps usually down a slope, while motorway exit ramps are upwards? Can the pupils explain the reasons behind this design in terms of forces and energy? (5–10 mins)</td>
<td>Teaching suggestions
• Special needs. You should provide templates or partially completed presentation for the ‘Forces and sports’ research task. These should provide guidance and some links to suitable websites.
• Extension. The pupils may be able to move further into their appreciation of the link between an unbalanced force by looking at the relationship:
Force = mass × acceleration.
They can use this to explain why larger vehicles need powerful engines to accelerate in the same way as smaller vehicles with less powerful engines.
• Learning styles
Visual: Drawing force diagrams.
Auditory: Discussing the effect of forces in sport.
Intrapersonal: Reviewing sources of information for research.
Interpersonal: Working in groups on the project.
• Homework. The research project lends itself well to homework if it cannot be completed in lesson time.</td>
</tr>
<tr>
<td colspan="2">Learning Outcomes
All pupils should be able to describe how the speed of an object is affected by balanced and unbalanced forces.
Most pupils should be able to explain how forces can affect both the speed and direction that an object is moving.
Some pupils should also be able to explain why an object moving in a straight line cannot have unbalanced forces acting on it.</td>
<td colspan="2">Additional teachers notes
Equipment and materials required
The pupils will need access to computers, a range of books, magazines and the internet. The book can be borrowed from the school library or perhaps the physical education department.</td>
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</table>

Fusion 3: P2.6 – It's a drag

National Curriculum Link up

•3.1b

Learning Objectives

Pupils should learn:

That air resistance acts against a moving object and increases as the speed of the object increases.

That drag can be reduced by streamlining an object.

Teaching / Learning activities

Lesson structure

Starter - Drag racers

Show the pupils a drag race: one where the cars use parachutes to slow down. Ask them to explain how the cars speed up and slow down. What features make a car a good dragster? (5–10 mins)

Main

The pupils should all be familiar with the general idea of an object being streamlined, especially cars, but they may not be aware of the extent that some athletes go to. You could discuss whether they think that these measures really make any difference.

Car efficiency is an important topic and the pupils need to be made aware just how inefficient it is to drive at very high speeds. This uses petrol up far more rapidly and increases the strain on an engine, potentially shortening its useful life.

Designing a streamlined object is not merely a matter of adding curves to it. A huge amount of computer simulation and wind tunnel experimentation is used. You could show the pupils some photographs of a wind tunnel in use, pointing out the smooth flow of air and the regions of turbulence.

Discuss the way vehicles have to push air out of the way in order to move through it; the faster they go the greater the force acting against them. Ask the pupils to imagine trying to walk through water; most should have done this in a swimming pool. They should appreciate that it is far more difficult than pushing themselves through the air: a process they hardly notice. Explain that they need to move a lot more water particles out of the way to go forwards and this needs a larger force.

The practical task **'Controlling drag'** can be a brief investigation. It is difficult to get anything but general results, because the pupils cannot really make anything but a general comparison about the shape of the objects that they drop. It is also difficult to time accurately when the drop distance is short.

The pupils can pool their conclusions and then discuss the limitations of the experiment. How could they make a comparison that is less general? Could they measure the cross-sectional area of the object falling? (How Science Works: evaluation)

Plenary - Streamline my ride

The pupils need to improve the streamlining of a very old car. Give them a drawing of the oldest design you can find and ask them to adapt the car using the most modern ideas. (10–15 mins)

Teaching suggestions

- **Extension.** The pupils could look into the problems of travelling at very high speed through the atmosphere. The frictional forces become so large that they heat up the aeroplane. Ask: 'How have scientists tried to overcome this heating problem in ultra-fast jets and the space shuttle?'
- **Learning styles**

Visual: Describing the shape of streamlined objects.

Auditory: Discussing the design of cars and other objects.

Kinaesthetic: Practical task.

Intrapersonal: Imagining the flow of air past a streamlined object.

Interpersonal: Sharing results and suggesting improvements.

- **Homework.** The pupils can prepare a report of 'car evolution', selecting a typical car design from each of the last ten decades to show how the shape has changed. Is efficiency or taste the driving force behind the improvements?

Learning Outcomes

All pupils should be able to identify streamlined and unstreamlined objects.

Most pupils should be able to describe how streamlining reduces the drag on an object in terms of moving material 'out of the way'.

Some pupils should also be able to explain why it is more difficult to move through a liquid, relating this to the density of the liquid and other possible factors.

How Science Works

Use and apply independent and dependent variables in an investigation by choosing an appropriate range, number and value for each one. (1.2b)

Additional teachers notes

Equipment and materials required

Each group: A long transparent cylinder, Plasticine and a stopwatch. Access to a top-pan balance. The tall glass container could be a large measuring cylinder or a clear Perspex tube sealed at one end. Tubes that are one metre long work well, but will need supporting.

Safety

Plastic containers should be used where possible to avoid breaking glass.

Fusion 3: P2.7 – Going up, coming down

National Curriculum Link up

•3.1b

Learning Objectives

Pupils should learn:

That objects fall towards the centre of the Earth due to the gravitational attraction causing an object's weight.

That a falling object accelerates until the drag matches the weight of the object.

Teaching / Learning activities

Lesson structure

Starter - Sentence

Give each pupil a different key word used in the topic so far (you may have to use each word twice) and ask the pupils to write a sentence using each one. The pupils can read out their sentences and you can see which are the most informative and scientific. (5–10 mins)

Main

You should discuss the idea of density when describing why a hot air balloon floats. This will help enhance the pupils' understanding of the particle model of matter and can help with the idea of gas pressure later. The pupils need to understand that the balloon rises because there is a larger force pushing upwards than the weight. This upwards force is an upthrust: the same type of force that acts on objects in water.

When discussing parachute drops, it is very useful to show video clips to demonstrate the ideas. There are a large number available on the internet. There are also several simulations or animations that show how the forces acting on a diver change throughout the fall. These make the explanations a lot easier to understand so use them if you can.

Describe the detail of the first graph to the pupils; this is a simplified picture of a parachute drop. It shows how the height changes and the pupils should be able to see that the parachutist is falling a lot slower near the end because the gradient of the graph is shallower.

When a parachute is opened a large upward force decelerates the parachutist. Some pupils will think that the parachutist actually moves upwards during this phase, because this is what seems to happen in video clips. The illusion is due to the cameraperson continuing to fall rapidly. If you actually did get pulled upwards the forces involved would be fatal.

The second parachute graph is a speed–time graph. Many of the pupils will think that this is the same as the earlier graph; however it actually shows different information. Make sure that the pupils see the difference; the *y*-axis now shows the speed that the object is travelling and the slope no longer shows the speed (it's the acceleration). Get the pupils to describe what is happening during each phase of the motion, to make sure that they understand what is happening.

Plenary - Recipe for disaster

Hydrogen gas is much less dense than air and much cheaper than helium, so why don't balloons use it? Let the pupils discuss the reasons. (5 mins)

Teaching suggestions

• **Special needs.** The pupils should be given some hints for the investigation. They should investigate one vehicle each using just one area, focussing on making the force measurement as reliable as possible. The groups can then share the data and reach a conclusion together.

• **Extension.** If you could make a balloon that has absolutely nothing inside it (a vacuum) then you could rise up to the top of the atmosphere. The pupils can discuss the possibility of this 'vacuum balloon' working. Could we every build such a device? Search the internet to find out some proposals.

• **Learning styles**

Visual: Watching video clips of parachutists.

Kinaesthetic: Measuring the force required to move objects.

Intrapersonal: Understanding the information on a speed–time graph.

• **Homework.** The pupils can find out about record sky dives. Ask: 'What was the longest fall? What is the fastest speed achieved, the largest group?' and so on.

Learning Outcomes

All pupils should be able to state that the motion of a falling object is affected by the weight of the object and the air resistance acting on it.

Most pupils should be able to describe how the forces involved in falling change during the fall.

Some pupils should also be able to interpret a graph showing an object falling through a fluid and describe the causes of the changes in speed in terms of the forces acting on the object.

How Science Works

Use and apply independent and dependent variables in an investigation by choosing an appropriate range, number and value for each one. (1.2b)

Additional teachers notes

Equipment and materials required

Dynamics trolleys, a range of forcemeters, metre rules, stopwatches, cardboard, tape, bags or cloth to make parachutes from and string.

Safety

Beware of falling objects.

Fusion 3: P2.8 – High pressure, low pressure

National Curriculum Link up

•3.1b

Learning Objectives

Pupils should learn:

That a force produces pressure when it acts over an area.

The size of the pressure is equal to the force divided by the area it acts over.

Teaching / Learning activities

Lesson structure

Starter - Define

Ask the pupils to give their definitions of the words 'pressure' and 'force' on mini-whiteboards. Ask them to hold the boards up and then discuss the range of definitions. (5–10 mins)

Main

Throughout this lesson, it is important to try to make sure that the pupils understand the difference between a force and the pressure it exerts on a surface. Many pupils think that the words are interchangeable and that pressure is just another type of force (like friction).

You can demonstrate pushing a drawing pin into a wooden block (or your wall). The point will easily penetrate wood, while the flat surface can't push through your skin even though the force is exactly the same in both cases. The area of the point is around 1 mm2, while your thumb is approximately 1 cm^2 (100 mm^2). This means that the pressure is about 100 times greater at the sharp end.

The calculations are relatively straightforward, but some pupils will need support with them nevertheless. Let the pupils have plenty of practice by measuring the pressure that a few objects exert on the floor.

The pupils could measure the pressure exerted by a range of basic objects by measuring their weight and the contact area between the object and a surface. Forcemeters can be used to measure the weight, while the area can be measured by drawing around the object while it rests on paper marked with 1 cm squares. These squares can then be counted to find the total area.

Once the pupils have mastered the calculation they can move on to the **'Piling on the pressure'** investigation. They should see patterns between the amount of compression and the pressure acting on a particular piece of foam fairly easily. Allow the pupils some freedom to choose exactly what they investigate and how they gather their results, in order to develop their planning skills. They should also focus on collecting the data in an organised manner, so that they can analyse it easily (How Science Works; planning, recording results and analysing data).

Plenary - Testing to destruction

Can the pupils plan a test to find out which material is the most resistant to being crushed, even though the samples they have are different sizes? They should outline a rough plan of their ideas. (5–10 mins)

Teaching suggestions

• **Special needs.** Provide a detailed plan or set of instructions for the investigation, so that the pupils can focus on collecting results. Different groups can work on different aspects and share their conclusions.

• **Extension.** The pupils should work on more demanding questions that include rearrangement of the pressure equation.

• **Learning styles**

Visual: Drawing tables and graphs of results.

Auditory: Discussing approaches to a task.

Kinaesthetic: Measuring compression.

Intrapersonal: Imagining the action of a force acting over an area.

Interpersonal: Sharing results and conclusions.

• **Homework.** The pupils could analyse the results of their investigation (or you could provide them with some suitable results), producing a graph and reaching a scientific conclusion, followed by an evaluation.

Learning Outcomes

All pupils should be able to compare the pressures produced by different forces acting over different areas qualitatively.

Most pupils should be able to calculate the pressure exerted on an area due to a force using the pressure equation (pressure = force/area).

Some pupils should also be able to use the pressure equation to solve a range of problems, including some that require rearrangement.

How Science Works.

Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)

Additional teachers notes

Equipment and materials required

A range of foam blocks, thin wooden boards, 50 g masses, mass holders and rulers.

Safety

Take care: masses and wood may fall onto pupils' feet.

Fusion 3: P2.9 – Pressure in liquids and gases

National Curriculum Link up
•3.1b

Learning Objectives
Pupils should learn:
That deeper into a liquid (or gas) the higher the pressure inside that liquid.

That liquids and gases exert pressure due to their particles hitting the sides of a container producing forces.

Teaching / Learning activities
Lesson structure
Starter - Fluidity
The pupils need to explain why gases and liquids are fluids but a solid isn't. What do they think a fluid is and why do they think that fluids can flow? (5–10 mins)
Main
Start with a demonstration of inflating a balloon. You could ask a pupil to blow up a particularly difficult balloon and then use a pump to get the job done. Don't forget to pop it with a pin; linking back to the previous lesson, ask: 'Why can the balloon be popped with a pin but not your thumb?'
Pupils will know that some people are concerned about their blood pressure. You can show what happens when the pressure gets too high using two plastic syringes full of water connected by rubber tubing. Wear a weak spot in the tubing beforehand (scrape most of the way through with a scalpel) and then push the liquid back and forth. Pushing both ends will increase the pressure and hopefully get the tube to rupture. Don't use red ink though.
You should be able to find some pictures of submarines, or even some video footage of them diving. The deeper the subs have to go, the stronger their structure needs to be and this is apparent in the design of small, deep-sea submersibles. These have spherical shaped windows to spread the forces evenly.
You can now demonstrate some of the effects of pressure in fluids. Make sure that the pupils know what you mean by a 'fluid' though. The demonstrations are straightforward and during them you need to be describing particle behaviour to lead on to the next part.
Remind the pupils about the particles in a liquid and gas by asking them to sketch them. Check the liquid diagrams carefully, as many pupils leave gaps that are too large between the particles in a liquid.
Plenary - Balloon in space
What would happen if a balloon was pulled higher and higher into the atmosphere, eventually reaching space? The pupils could describe (or draw) their ideas and explain them using the particle model. (5–10 mins)

Teaching suggestions
• **Special needs.** Use animation or simulation to reinforce the explanation of how fluids behave using the particle model.
• **Extension.** There is an opportunity here for the pupils to look at how particle theory has developed in science. They could be asked to look into the development of the ideas over the last two thousand years and see if they can find any 'proof' that there are particles at all.
• **Learning styles**
Visual: Imagining particle behaviour in fluids.
Auditory: Listening to explanations of how the particle
model explains pressure.
Kinaesthetic: Popping balloons in a quiz.
Intrapersonal: Understanding the behaviour of particles in a fluid.
• **Homework.** When divers rise too quickly from deep dives they can be affected by 'The bends'. The pupils can find out what this is and how it can be avoided.

Learning Outcomes
All pupils should be able to state that the pressure (in a fluid) increases with depth.
Most pupils should be able to describe the cause of pressure in terms of particle behaviour.
Some pupils should also be able to use the particle model to explain why pressure increases with depth in a fluid.

Additional teachers notes
Equipment and materials required – 2 demos - Balloons for inflating, balloon pump, pin. Two plastic syringes, rubber tubing (weakened in the centre). **Pressure in fluids** - A water pressure demonstration cylinder (or improvised version). Collapsing can: A metal can (these are specifically designed for the demonstration), vacuum pump and connecting tubes or heating apparatus and access to water.
Safety. Demonstrate the can behind a safety screen and be very careful not to burn yourself. Water uring out the canister can spill onto the floor and create a slipping hazard.

Fusion 3: P2.10 – Levers everywhere

National Curriculum Link up
•3.1b

Learning Objectives
Pupils should learn:
That a lever is a simple machine that can be used to magnify the size of a force.

That a lever requires a pivot and an effort force to operate.

Teaching / Learning activities
Lesson structure
Starter - Nailed it
Show the pupils a nail hammered most of the way into a block of wood and demonstrate how difficult it is to pull out by hand. Ask them to come up with some ideas about how to remove the nail with the minimum of effort. Finally demonstrate how simple it can be using a claw hammer. (5–10 mins)
Main
You can start the lesson by showing a range of simple levers in action. This should show that levers can be more than just simple bars and they are extremely useful. Emphasise that the levers are helping you increase the force that you can apply to an object.
During the lesson you should use the generic terms 'effort', 'pivot' and 'load' as often as possible, so that the pupils become used to using the terms automatically instead of using phrases like 'the push' and 'hinge'.
Once you have covered these points, you can let the pupils examine some simple levers using the **'A look at levers'** task. When they look at scissors, ask them about which bit of the blade it is easiest to cut with; they should find that this is near the pivot.
Some pupils may want to talk about the levers in the human body, such as the arm. If you have time, you can show them the actions using models or some simulation software. The human arm is not a lever that actually makes it very easy to lift heavy objects. If you hold a heavy object with your arm horizontal, the load is about 50 centimetres from the pivot (your elbow), while the effort is only 1 centimetre or so away. This means that the muscle has to produce a force 50 times greater than the weight you are holding. Holding an object at arms length is very tiring. On the other hand, the advantage is that a small contraction of the muscle produces a large movement.
The final part of the lesson moves on to the turning effect of a force. This will be the focus of the next lesson when the pupils calculate the size of this effect and look into balancing, but for now they need to be aware that you can increase the amount of this 'turn' by pushing further away from the pivot.
Plenary - Invention
The pupils can design their own invention that uses levers to complete some task. This could be picking an object up at a distance, opening a door automatically and so on. (10–15 mins)

Teaching suggestions
• **Extension.** The pupils will find it easier to label a set of diagrams of levers if they are provided with them during the practical task.
• **Learning styles**
Visual: Labelling diagrams of levers.
Auditory: Discussing how the levers work.
Kinaesthetic: Examining levers and lever-based devices.
Intrapersonal: Thinking about the action of a force around a pivot.
Interpersonal: Giving feedback about the levers that have been investigated.
• **Homework.** Can the pupils find out more about human joints and how muscles are used to move our body? Their report should include mention of antagonistic pairs of muscles and the fact that muscles can only contract.

Learning Outcomes
All pupils should be able to give examples of simple levers.
Most pupils should be able to label the location of the pivot, effort force and load force on a simple lever in action.
Some pupils should also be able to use the concept of a turning effect to explain how a larger force can be produced from a smaller one.

Additional teachers notes
Equipment and materials required – Starter - Hammer, nail, wood, claw hammer.
'A look at levers' - Some example levers and objects that use the lever principle (scissors, claw hammer etc.).
Safety. This depends on the levers used. Take care with cutting and crushing tools.

Fusion 3: P2.11 – Getting balanced

National Curriculum Link up

•3.1b

Learning Objectives

Pupils should learn:

That the moment of a force is the force multiplied by the (perpendicular) distance to the pivot?

That a lever is balanced when the moments in one direction are equal to the moments in the other direction (clockwise and anticlockwise)

Teaching / Learning activities

Lesson structure

Starter - A balancing act

Show the pupils photographs or video of a tightrope walk or gymnast on the beam. Ask them how the participants manage to balance on such thin objects and discuss the level of skill involved. (5–10 mins)

Main

Although see-saws are the most common examples used to describe moments, and the easiest way to introduce the calculations, the ideas and calculations are valid for any pivoted object. Make sure the pupils think about other situations, for example car park barriers, cranes, gymnasts on a beam and so on.

The calculation of a moment is not difficult, but the pupils should be shown how to write down the calculation carefully as shown in the pupil book. This is particularly important if the pupils are dealing with several forces acting on a ruler where they need to add the individual moments.

When describing turning effects it is best to use the terms clockwise and anticlockwise instead of alternatives such as left and right. The pupils need to recognise the phrase 'principle of moments' and link it to the idea that an object is balanced because the clockwise and anticlockwise moments are the same.

The pupils can now try the practical task **'Testing the principle of moments'**. They will need to calculate the moment on each side of the ruler to see if they match; a well-designed results table makes this process much easier, so make sure that the pupils plan it properly (How Science Works: recording results).

The pupils will probably measure the distances in centimetres during the experiment. You can ask them to convert the distances into metres before their calculations or explain that it is OK to measure the turning effect in newton centimetres as long as they do this for all the distances.

At the end of the task, ask the pupils to discuss their results and conclusions. They should point out the difficulties they had getting the objects to balance exactly and positioning the masses accurately. You can ask them to design an improved experiment or a simple list of a few possible improvements. (How Science Works: evaluation)

Plenary - Final force

The pupils have reached the end of the physics-based topics. Give them a set of summary questions to check for weak points in their understanding, so that these can be revisited. (10–15 mins)

Teaching suggestions

• **Special needs.** The calculations can be extremely challenging to some pupils. Provide them with a detailed step-by-step method and only use problems with simple numbers.

• **Extension.** The pupils should be challenged to solve more complex moment questions. These can involve multiple masses on each side of a see-saw or the rearrangement of the equations. They can also tackle see-saws that are not balanced beneath their centre of gravity so they have to take this into account.

• **Learning styles**

Visual: Examining and drawing 'see-saw' diagrams to solve problems.

Auditory: Discussing when objects will be balanced.

Kinaesthetic: Balancing levers.

Intrapersonal: Understanding the conditions for an object to be balanced.

Interpersonal: Collaborating in group practical work.

Learning Outcomes

All pupils should be able to state that the turning effect of a force is called its moment.

Most pupils should be able to calculate the moment due to a force acting around a pivot.

Some pupils should also be able to use the principle of moments to decide if an object is balanced or in which direction it would rotate.

How Science Works.

Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)

Additional teachers notes

Equipment and materials required

Half-metre rulers (ones with holes drilled every 5 cm are best), 50 g masses, bench protector, a method of pivoting the ruler (see below).

Safety

The pupils should take care not to drop heavy weights onto their feet.