<table>
<tr><td colspan="4">Fusion 2: P1.1 – Light from Space</td></tr>
<tr><td colspan="4">National Curriculum Link up
•1.1a, b. 2.1a, b, c. 3.1a, b. 3.4b.</td></tr>
<tr>
<td>Learning Objectives
Pupils should learn:
That light rays travel in straight lines.
That we see objects when light rays are reflected off them and enter our eyes.</td>
<td colspan="2">Teaching / Learning activities
Lesson structure
Starter -Under the sea
Show the pupils a slideshow of creatures that live deep in the ocean. Use images of species that produce their own light along with some that are completely blind. (5–10 mins).
Main
Use the 'Seeing the light' demonstration to get across the concept of a ray. Show the pupils the hazard symbol for laser light and discuss what it means including the potential damage to the retina. The ray should look very straight and sharp. Use this to emphasise that a ruler must always be used when drawing rays to ensure accuracy. Ask the pupils to draw a simple diagram of a light ray to check that they do this.
The ideas concerning how we see objects were debated by the ancient Greeks. The Greek philosophers tended towards the idea that light was sent out from the eye so that we could see things. There were obvious problems concerning why we could not see as well at night or in a cave, but various God-related explanations for this were proposed. The Muslim scientist Ibn al-Haytham seems to have settled the matter in detail with his Book of Optics in the early 1000s. This covered quite a lot of what we now know of as optical theory. This links in well with the key concept of cultural understanding where science has its roots in different societies.
Be careful with the idea that we see objects when they give out light; most objects simply reflect light from the actual sources of light. Mention the ideas of a light source at this stage if it has not already come up.
Plenary - Shiny happy people
Many people love sunlight. Discuss whether sitting out in the Sun is good or bad for us. Most will know that sunlight can damage the skin, but do any know of any benefits? (5–10 mins)</td>
<td>Teaching suggestions
• Learning styles.
Visual: Watching demonstrations of light travelling.
Auditory: Discussing the effect of light on our eye.
Kinaesthetic: Drawing ray diagrams.
Intrapersonal: Making observations about the behaviour of light.
• Special needs.
Provide the pupils with cartoons showing the two possible explanations about how we see things. Ask them to add notes to these explaining which is most likely to be correct.
• Extension.
The pupils could look into how the idea that light travels in straight lines was developed. There is a rather interesting history of the optical theory starting with
Ibn al-Haytham (sometimes referred to as 'Alhacen') and leading up to Newton, Huygens and even Einstein, where the whole idea of 'straight lines' becomes a bit stranger as space itself becomes curved by gravity.</td>
</tr>
<tr>
<td colspan="2">Learning Outcomes
All pupils should be able to state that light travels in straight lines.
Most pupils should be able to explain, using a simple ray diagram, that we see objects when light travels from them into our eyes.
Some pupils should also be able to explain why it is not possible that we see by emitting energy from our eyes.
How Science Works
Describe more than one model to explain the same phenomenon and discuss the strengths and weaknesses of each model (1.1a1).</td>
<td colspan="2">Additional teachers notes
Equipment and materials required
A low power laser light source (a laser pointer pen is suitable if it is clamped in position; some modern 'spirit levels' use low power laser light and these are also suitable), chalk dust or talc to show the beam path. Safety. Laser light can be damaging to the eyes, even at the level from a low power laser. The laser must be pointed away from all pupils onto a matt surface to avoid the possibility of an intense beam of reflected light reaching the pupils' eyes. Domestic lasers are not always calibrated or categorised correctly. Store securely. More info on CLEAPSS CD-Rom/handbook section 12.12 and PS52. The teacher must do a risk assessment and make their own decision based upon the class.</td>
</tr>
</table>

Fusion 2: P1.2 – Straight-line Light

National Curriculum Link up
•3.1a.

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: That light (and infra-red) rays travel in straight lines. That light travels at the fastest possible speed.	**Lesson structure** **Starter - A level playing field** How can the pupils show that their desks are level? The pupils should come up with as many ways as possible to check this using simple equipment. (10–15 mins). **Main** The first method in the 'Light line-up' activity is straightforward but can be a bit challenging to get just right. It is worth trying this method before the second, more traditional one, as it shows the three-dimensional nature of light travelling which is not usually clear in optical experiments. The second method is much simpler and introduces the techniques required to use ray boxes successfully. Once the pupils are convinced that light is travelling in straight lines, you can move on to testing infra-red with the 'Zapper test' activity. This develops skills in investigatory work to an appropriate level. If you decide to test these out, the results will often show that the rays don't have to travel in straight lines. This is because the LED on the remote control spreads infra-red radiation in a wide beam, so doesn't have to be pointing at the sensor. To overcome this, you should add narrow cardboard tubes to both the transmitter and receiver. **Plenary - Speed-o-meter** Give the pupils a set of cards with a range of moving objects depicted on them: a snail, bicycle, car, plane, sound wave, light and some others. Can they put them in order of slowest to fastest? (5 mins)	• **Special needs.** Provide the pupils with some 'ideas cards' that give them clues about how to design the 'Zapper test' experiment. • **Extension.** The pupils can look into the International System of Units (SI) to find out why the speed of light is known exactly whereas other speeds are not. The pupils could also look at some of the other fundamental units used in physics: kilogram, second, ampere etc. • **Learning styles.** *Visual:* Observing ray paths. *Auditory:* Discussing the significance of the speed of light. *Kinaesthetic:* Careful manipulation of equipment in practical task. *Interpersonal:* Working in groups to plan an experiment. *Intrapersonal:* Thinking about and evaluating the ray model for light. • **Homework.** The pupils could try the 'Excellent Adventure' plenary at home and write a bit more about their visit. Perhaps a pupil has *already* brought this homework in. • **Functional skills link-up. Mathematics** Carry out calculations with numbers of any size (level 2).

Learning Outcomes	Additional teachers notes
All pupils should be able to describe a method to show that light travels in straight lines. *Most pupils should be able to* describe an experiment that can be used to test whether or not infra-red rays also travel in straight lines. *Some pupils should also be able to* state that light travelling in a vacuum travels at the fastest speed possible but travels at lower speeds in other materials. **How Science Works** Describe an appropriate approach to answer a scientific question using sources of evidence and, where appropriate, making relevant observations using appropriate apparatus (1.2a).	**Light line-up (Method 1) equipment and materials required for each group:** three pieces of card, cotton on a large needle, three retort stands and boss and clamps, light source. **Safety.** Needles (if used) will be very sharp. **Light line-up (Method 2) equipment and materials required for each group:** ray box with suitable power supply, blanking plates and a single slit, A4 white paper, pencil and ruler. **Safety.** The filament lamps in ray boxes can become very hot and should be handled with care especially when they are being put away.

Fusion 2: P1.3 – Materials and Light		
National Curriculum Link up •3.1a.		
Learning Objectives **Pupils should learn**: That materials can be described as transparent, opaque or translucent depending on how light passes through them. That light energy can be absorbed or transmitted by materials. How to measure the intensity (brightness) of a light source.	**Teaching / Learning activities** **Lesson structure** **Starter - Group theory** Let groups of pupils examine the materials that they will be using during the lesson and a few extra ones. They have to sort the materials into three groups and then explain what the groups are to you. Once they have done this they have to sort the materials into three entirely different groups and explain their decisions again. (5–10 mins) **Main** The pupil can then categorise the materials using the 'Examining materials' activity. To perform the 'Measuring light' activity, the pupils will need access to a set of light sensors or meters. The focus should be on taking numerical measurements so that a true comparison can be made. The practical can be performed as a demonstration but isn't nearly as effective. The pupils should concentrate on making the test fair. The final part of the lesson focuses on three more key words: absorb, transmit and reflect. **Plenary - Illuminate me** The pupils make a list of all of the scientific terms (transparent, opaque, translucent, absorb, transmit, reflect and scatter) and give definitions for them. Check these carefully. (5–10 mins)	**Teaching suggestions** • **Special needs.** Provide diagrams showing a light ray being transmitted, reflected, absorbed etc. and allow the pupils to label these with the correct scientific terms. • **Extension.** The pupils can find out about how the eye operates and, in particular, how it adapts to different light levels. Just how sensitised is a 'dark-adapted eye' and how does it detect light? Warn pupils not to look directly at the Sun. • **Learning styles** *Visual:* Observing the effect of different materials on light. *Auditory:* Discussing the uses of various materials. *Kinaesthetic:* Measuring light intensity. *Interpersonal:* Discussing the uses of various materials. *Intrapersonal:* Thinking about the interactions light has with materials. • **Homework** The pupils can design improvements for the 'Measuring light' experiment based on their experiences.
Learning Outcomes *All pupils should be able to* place materials into the categories transparent, opaque and translucent. *Most pupils should be able to* measure the intensity of a light source and compare the transparency of materials. *Some pupils should also be able to* evaluate an investigation into measuring the transparency of different materials. **How Science Works** Describe and identify key variables in an investigation and assign appropriate values to these (1.2b).	**Additional teachers notes** **Examining materials equipment and materials required e**ach group needs access to some of the following materials: glass (a block), Perspex, polythene: thicker sheets or strips, paper, tracing paper, wood, wax (thin is best), sheets of plastic filters (red, green, blue) and black plastic bin liners. Other materials can also be used. **Safety.** If glass materials are used then they need to be handled with care. Check for sharp edges; tape or file them if necessary. **Measuring light equipment and materials required:** The pupils need access to some of the materials used in the previous experiments along with light sensors, rulers and lamps. Some sensors need to be connected to data-logging equipment to operate and so this equipment may be required. **Safety.** The lamps may become hot with prolonged use. The pupils should not stare directly into the light.	

Fusion 2: P1.4 – Mirror, Mirror on the Wall …

National Curriculum Link up

•3.1a.

Learning Objectives

Pupils should learn:

That we can see images in mirrors because they reflect light.

About the properties of these images.

That the law of reflection is that the angle of incidence is equal to the angle of reflection.

Teaching / Learning activities

Lesson structure

Starter - Set the pupils a few questions about light that are written in mirror text. They have to use a mirror to read the questions and then answer them. Bonus marks if they can write the answers backwards too. (10–15 mins).

Main

During the first part of the lesson the pupils should freely examine mirrors, looking at images of themselves.

You can show that the image in a mirror is as far behind it as the object is in front by this simple technique: hold a 30 cm ruler under your nose pointing outwards. Hold a plane mirror at the end of it so you can see the image; the image you see is two ruler lengths 'away' from you so it's 30 cm behind the mirror.

The 'Investigating reflection' activity itself is straightforward and the results will be good if the pupils measure the reflection from the back surface of the mirror. You can also use a reflection simulation to show that the angles are the same. This is best used as a summary after the pupils have convinced themselves it works in real life.

Towards the end of the lesson the pupils can make a periscope or kaleidoscope with the 'Multi-mirror miracles' activity.

Plenary - Reflecting on progress

A poor pun, but the pupils have covered some very important concepts recently so a mini-quiz can be used to check understanding. (10 mins)

Teaching suggestions

• **Special needs.** Use a worksheet with the mirror position, incident rays and a protractor printed onto it to make taking the readings more straightforward.

• **Extension.** What's special about mirrors? Why can we see images in mirrors and on the surface or water or glass but not on the surface of white paper? The pupils must come up with a reason for this that includes a diagram. They could also find out about the different layers in a standard mirror or how to make a 'perfect' mirror.

• **Learning styles**

Visual: Observing ray paths and taking precise measurements.

Auditory: Discussing patterns in their results.

Kinaesthetic: Making precise measurements of angles.

Intrapersonal: Thinking about what an image in a mirror actually is.

• **Homework.** The pupils can find out about some of the uses mirrors are put to. Where are the world's largest mirrors? Are all mirrors fl at? What can curved mirrors do to the image you see? As an alternative, pupils could design a device of their own that uses mirrors.

Learning Outcomes

All pupils should be able to state the law of reflection.

Most pupils should be able to describe the properties of an image formed in a plane mirror.

Some pupils should also be able to describe how an image is formed by a mirror using a ray diagram.

How Science Works

Explain how the observation and recording methods are appropriate to the task (1.2d).

Additional teachers notes

Investigating reflection equipment and materials required per group: a ray box, power supply, blanking plates (stops) and single slit. A sheet of white paper, pencil, ruler and protractor. **Safety.** Check for chips in the glass mirrors as these can lead to minor cuts when the mirrors are handled; tape edges if necessary. Be aware of hot ray boxes.

Multi-mirror miracles equipment and materials required for each pupil: card (the thicker the card the more sturdy the periscope or kaleidoscope), two (periscopes) or three (kaleidoscopes) plastic mirrors, scissors and tape (or glue). Small glass mirrors can be used, but these are heavier and can lead to cuts. **Safety.** If glass mirrors are used then watch out for glass breakage.

<table>
<tr><td colspan="4">Fusion 2: P1.5 – Rays that Bend</td></tr>
<tr><td colspan="4">National Curriculum Link up
•3.1a.</td></tr>
<tr>
<td>Learning Objectives
Pupils should learn:
That light rays refract (change direction) when they move from one medium to another.
That the amount of refraction depends on the two materials involved.</td>
<td colspan="2">Teaching / Learning activities
Lesson structure
Starter -Is it all in your mind?
There are a wide range of optical illusions, some based on static images and some based on moving ones. Show the pupils some of these and ask them to explain what they see. (10–15 mins)
Main
Start by demonstrating the illusions mentioned in the pupil book, see the ‘bending pencils, disappearing coins’ information or use ‘The vanishing’ starter before the scientific tricks. It can be difficult for all of the pupils to see the tricks, especially the coin one. If you have a data projector and video camera then use these to project the tricks onto a screen so that everybody gets a clear view.
Explain the tricks in terms of light changing direction when it moves between two materials (media). Use the idea of bending towards the normal and away from it. Make sure that the pupils do not get the impression that the light rays are curving as they pass through the material.
The main focus of the lesson is the ‘Investigating refraction’ activity and the results of this will show if the pupils can meet the objective of making accurate measurements with unusual apparatus: the protractor.
Plenary - Going off the deep end
The pupils must produce a scientific warning sign to prevent people jumping into deep water accidentally. They must include the scientific reasons. (10–15 mins)</td>
<td>Teaching suggestions
• Special needs. You can provide partially completed ray diagrams for the ‘Investigating refraction’ activity to show suitable angles for the rays to enter the block and the position of the block itself. This makes it simpler to get the expected results.
• Extension. What is the cause of refraction? The pupils can find out about changes in the speed of light as it enters or leaves materials (media). What is a refractive index and what is the relationship to the speed of light (or even the angles of refraction and incidence)?
• Learning styles
Visual: Observing tricks and optical phenomena.
Auditory: Discussing their ideas about how tricks work.
Kinaesthetic: Carrying out an investigation into refraction.
Interpersonal: Working in groups to obtain results.
• Homework. The pupils can find out about refraction at curved surfaces; what are lenses, where are they used and how do they work? As an alternative, the pupils could find out and learn to perform a magic trick for themselves.
• Functional skills link-up. Mathematics
Recognise and use 2D representations of 3D objects (level 2).</td>
</tr>
<tr>
<td colspan="2">Learning Outcomes
All pupils should be able to state that light is refracted when it moves from one material to another.
Most pupils should be able to show, using a ray diagram, how light is refracted as it enters and leaves a glass block.
Some pupils should also be able to explain why a pool of water appears to be shallower than it really is.
How Science Works
Explain how the observation and recording methods are appropriate to the task (1.2d).</td>
<td colspan="2">Additional teachers notes
Bending pencils, disappearing coins (demonstration) equipment and materials required: A large transparent container (a 500 cm3 beaker is fine), water, a pencil, a coin and bowl.
Investigating refraction equipment and materials required each group: glass (or good Perspex) block, ray box, power supply, stops, single slit, protractor, A3 paper, pencil and ruler. Safety. The lamps in the ray boxes will become hot during use. Glass blocks may have sharp edges; tape if necessary.</td>
</tr>
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<table>
<tr><td colspan="4">Fusion 2: P1.6 – Colours of the Rainbow</td></tr>
<tr><td colspan="4">National Curriculum Link up
•3.1a.</td></tr>
<tr>
<td>Learning Objectives
Pupils should learn:
That white light is composed of a spectrum of colours.
That filters transmit some colours while absorbing others.
That coloured objects can appear to be different colours from their actual colour when they are viewed through filters.</td>
<td colspan="2">Teaching / Learning activities
Lesson structure
Starter - Colour match
Show the pupils a picture of a rainbow. Most will tell you that there are only seven colours. Now give them a few dozen colour squares cut out from a paint catalogue. The pupils must sort them into order. Finally challenge them to match up the names to the colours. This should show them that the seven colours are a bit arbitrary. (10–15 mins)
Main
The ‘Making spectra’ demonstration should clearly show that white light is composed of a range of colours we call the spectrum.
Let the pupils look at a range of coloured objects through a sample filter and ask them to explain what is happening themselves. You can use some coloured slides as mentioned in the ‘Hidden messages’ activity.
To prove that light is being absorbed by the filter, as opposed to being changed, you should measure the light intensity before and after the filter using a sensor. There should be a clear reduction in intensity; showing that energy is absorbed by the filter. Show that every colour filter absorbs some of the energy from the light.
The pupils can then try out the ‘Hidden messages’ activity to check their understanding. They should be able to describe what they are seeing in terms of absorption and transmission of different colours.
Plenary - Flagging
Show the pupils a set of national flags as they would be seen through a coloured filter. Can the pupils identify the country the flags belong to? (5 mins)</td>
<td>Teaching suggestions
• Special needs. The pupils should draw ray diagrams showing white light passing through filters and/or reflecting off coloured objects. They can use coloured pens to show the separate colours (red, green and blue or all seven). For example when the white light passes through a red filter, the red ray would continue while the other colours would stop.
• Extension. The pupils can look beyond the visible spectrum. They can find out about infra-red and ultraviolet radiation and their effects. You can demonstrate UV with a low powered UV fluorescent tube (no staring into the lamp) and a special marker pen. (Safety: do not look directly at the ultraviolet source.) To show infra-red use an IR sensor, or place a thermometer just beyond the red part of the spectrum you produced earlier to see a temperature rise.
• Learning styles.
Visual: Identifying shapes and flags through filters.
Auditory: Discussing the processes that are happening to light as it passes through a filter.
Kinaesthetic: Drawing out hidden messages or images.
Interpersonal: Working in groups to sort colours.
Intrapersonal: Designing a message or picture based on an understanding of filters.
• Homework. The pupils can design additional, more detailed, images to be viewed through a filter to see what they would look like. They could prepare presentations.</td>
</tr>
<tr>
<td colspan="2">Learning Outcomes
All pupils should be able to state the colours (ROYGBIV) of the spectrum.
Most pupils should be able to describe how a coloured filter affects white light.
Some pupils should also be able to explain why coloured objects appear as they do when viewed through coloured filters.</td>
<td colspan="2">Additional teachers notes
Making spectra (demonstration) equipment and materials required:
Two identical 60° prisms (the larger the better), a beam of bright white light (from a ray box and power supply) and a sheet of white A3 paper. Safety. The pupils must not stare into the bright light. Prisms may have sharp edges; tape if necessary.
Hidden messages equipment and materials required: A range of coloured filters including red, green and blue, a set of pens with very similar colours to the filters, some white and coloured paper to write on. Safety. Look out for sharp edges on prisms. Do not look directly at bright light sources.</td>
</tr>
</table>

Fusion 2: P1.7 – Sources of Light

National Curriculum Link up

•3.1a, b. 3.4b.

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: That stars are visible because they are sources of light. That planets and the Moon are visible because they reflect light from our Sun.	**Lesson structure** **Starter** -**Relative brightness** Give the pupils a set of cards with different light sources on them. They have to discuss the brightness (luminosity) of the source and put them in order. Use the following sources: a match, a candle, a torch, a car headlight a lighthouse, the Sun, and the pole star (a bright star). [The pole star (Polaris) is much brighter than the Sun but it is a lot further away.] (5–10 mins) **Main -** The 'Seeing sunspots' activity can be carried out as a demonstration unless you have several sets of binoculars or telescopes. Ask the pupils to perform a basic risk assessment before you, or they, carry out the task. The pupils should have a good knowledge of night and day. Let them carry out the 'Day and night on Planet Football' activity to check this. Afterwards you can reinforce the ideas using a globe and lamp to make sure that they are clear about the details. The pupils should be asked about the flaws in the model you are using [the lamps should be much, much further from the Earth and much, much larger than it]. Computer animations can be used to support the ideas shown in a real model too. **Plenary - Rings** Show an image of Saturn with its rings in shadow. Ask the pupils to describe how this supports the idea that the Sun is the only source of light in the solar system. A video clip of a moon moving into or out of the shadow region would be even better. (5–10 mins)	• **Special needs.** Provide a list of instructions for the 'Day and night on Planet Football' activity. These can lead the pupils to look at different sized and coloured objects. • **Extension.** The pupils can look at the sunspot cycle. Do the spots appear at random or is there a pattern? What does this pattern tell scientists about the Sun? • **Learning styles** *Visual:* Making observations of sunspots or discussing their images. *Auditory:* Explaining why planets are illuminated only one half at a time. *Kinaesthetic:* Investigating illumination via a model. *Intrapersonal:* Considering how historical observations have helped to develop modern ideas. • **Homework.** Some pupils may want to keep records of sunspots over a period of a couple of weeks. Alternatively the pupils can find out about the length of the days on the different planets in the solar system.

Learning Outcomes	Additional teachers notes
All pupils should be able to state that the Sun is the source of light in our solar system and planets reflect some of this light. *Most pupils should be able to* explain that the Sun gives out light energy because it is at a very high temperature. *Some pupils should also be able to* explain the relative brightness of the planets in terms of the size, colour and distance from them. **How Science Works** Explain how to take action to control the risks to themselves and others, and demonstrate competence in their practical techniques (1.2c).	**Seeing sunspots (demonstration) equipment and materials required:** A pair of binoculars, retort stand, boss, clamp, solid screen and sheet of paper. **Safety.** The Sun should never be observed directly through binoculars or telescopes at any time. Permanent eye damage will result. CLEAPSS PS17 'viewing the sun'. **Day and night on Planet Football equipment and materials required:** A ball (on string if possible) and a lamp. **Safety.** The lamp may be hot (use a low energy bulb if intense enough). See CLEAPSS guide L194.

<table>
<tr><td colspan="3">Fusion 2: P1.8 – Solar System</td></tr>
<tr><td colspan="3">National Curriculum Link up
•3.1a. 3.4b.</td></tr>
<tr>
<td>Learning Objectives
Pupils should learn:
That scientists gather information about planets by making observations with telescopes or sending probes to the planet.
That conditions on the other plants in the solar system are very different to those on Earth.</td>
<td>Teaching / Learning activities
Lesson structure
Starter - Constellation consternation
Give the pupils some diagrams of constellations, just the star positions. They have to draw what they see in the patterns. Once they are finished, show them what the ancient societies thought that the patterns were. (5–10 mins)
Main -
Show the pupils a simple convex (converging) lens. Now show the pupils a real telescope if you have one available. If you don't have a telescope, or want a practical task, the pupils can build a small astronomical telescope. See the 'Telescope building' activity in 'Additional teachers notes'. You could ask them to improve this basic design.
The pupils can then discuss what they already know about the solar system. Our picture of the solar system has changed radically and a whole lesson, if one is available, could be set aside for the pupils to look at the changes in ideas.
The 'Planetary explorer' activity will take up the major part of this lesson. The main goal of the activity is to compare conditions to those on Earth. Temperature, length of year and day are the most important aspects to look at, but the pupils are sure to want to include a lot more detail.
Once the pupils have chosen a planet, they can design the mission to explore it. Remind them that any probe sent must be able to survive the conditions on the planet. This part of the activity could be set as a homework task, as some pupils will want to spend quite a bit of time on their design.
Plenary - Tiny planets
The pupils have to describe all of the planets clearly in the fewest words possible. [For example, 'red rocky mini moons' for Mars.] (5–10 mins)</td>
<td>Teaching suggestions
• Special needs. Provide the pupils with a range of specially chosen websites to use for the research project, so that they do not get swamped with the information available.
You may want to set just one website backed up with a few textbooks.
• Extension. The pupils can investigate the patterns in the whole solar system. What happens to the surface temperature and length of the year as you move further away from the Sun, etc.? Alternatively the pupils could look at the variety of planets that have been discovered in other solar systems.
• Learning styles
Auditory: Discussing the conditions on different planets.
Kinaesthetic: Examining or building a telescope.
Interpersonal: Debating what a planet is (and what isn't a planet).
Intrapersonal: Thinking about the requirements of a manned exploration of the solar system.
• Homework. The pupils can develop their ideas and designs for planetary exploration (see Main lesson).</td>
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<tr>
<td colspan="2">Learning Outcomes
All pupils should be able to describe the basic structure of the solar system.
Most pupils should be able to describe the methods used to explore the solar system.
Some pupils should also be able to explain why it is difficult to investigate planets using manned exploration.</td>
<td>Additional teachers notes
Planetary explorer equipment and materials required: Access to textbooks and the Internet.
Telescope building equipment and materials required for each group: a 50 cm ruler, two converging lenses (5 cm and 30 cm) and some Plasticine. Safety. The pupils must not use the telescope to observe the Sun. Glass lenses may have sharp edges.</td>
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Fusion 2: P1.9 – Phases of the Moon

National Curriculum Link up
•3.1a. 3.4b.

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: That the phases of the Moon are caused by different parts of the Moon being illuminated by the Sun at different times. That all objects in the solar system are only lit over half of their surfaces; the half pointing towards the Sun.	**Lesson structure** **Starter - Utter lunacy!** Get the pupils to list all of the non-scientific ideas about the Moon they have heard: 'it's made of cheese', 'it turns people into werewolves', and so on. Discuss why the ideas are not scientific. They may come up with a couple of scientific ones that they don't believe, so watch out. (10 mins) **Main –** The pupils can then carry out the 'Modelling the Moon' activity to check their understanding. They should eventually be convinced that they would see the same shapes as the phase pictures they have seen. Let one of the groups demonstrate their techniques to the others to consolidate. It is important that the pupils discuss how effective their models are for this, and then experiment. Are they realistic enough to reach valid conclusions? In 'The Earth from the Moon' the pupils again test out their understanding. They should find that any lunar colonists would see phases just like those found by observing the Moon There aren't as many pictures showing the phases of the Earth as there are showing the Moon. Take the opportunity to ask the pupils why they think this is. Where would you need to be to take the pictures and how many people have been able to do this? **Plenary - Inconstant Moon** The pupils should write a short poem or piece of prose that incorporates the ever-changing phases of the Moon. Can they beat Shakespeare? (5–10 mins)	• **Special needs.** Give the pupils some instructions about how to set up their Earth and Moon models and provide them with a set of circles they can colour in to show their observations. • **Extension.** What do the phases of the Moon look like from the southern hemisphere? Would they be exactly the same? The pupils can try to model this by putting the Moon below the Equator in their models. They should find that the Moon 'appears' from the opposite side. • **Learning styles** *Visual:* Describing diagrams showing the phases of the Moon. *Auditory:* Discussing the evidence for phases of the Earth. *Kinaesthetic:* Manipulation of the Earth–Moon model. *Interpersonal:* Working in teams to make the best model of the phases. • **Homework.** The pupils can find out about the history of lunar exploration. This can be from the very earliest of maps, through the manned landing and even towards a possible future expedition.

Learning Outcomes	Additional teachers notes
All pupils should be able to state that the phases of the Moon are caused by the different ways it is lit by the Sun. *Some pupils should be able to* describe how the phases are caused in detail. *Some pupils should also be able to* expand these ideas to explain how all of the objects in the solar system are illuminated and how this causes their appearance to vary when viewed from the Earth. **How Science Works** Describe how the use of a particular model or analogy supports an explanation (1.1a1).	**Modelling the Moon equipment and materials required: An** angle-poise lamp, a ping-pong ball (Moon) and a ball around the size of a small football (Earth). (A round balloon can work as an alternative Earth.) The balls can be attached to cotton or supported on sticks so that the pupils can move them about. See CLEAPSS Guide L194. **Safety.** The lamps will become hot with use (using a low energy bulb will keep the temperature down). **The Earth from the Moon equipment and materials required:** As above. **Safety.** The lamps will become hot with use (using a low energy bulb will keep the temperature down).

Fusion 2: P1.10 – The Seasons

National Curriculum Link up

•3.1a. 3.4b.

Learning Objectives

Pupils should learn:

That weather patterns change during the course of a year due to the Earth's axial tilt.

That the changes in day length and temperature are more extreme further from the Equator.

That different cultures describe seasons differently.

Teaching / Learning activities

Lesson structure

Starter - A year in the life

Ask the pupils to look out of the windows, or an imaginary view. They must draw a comic strip showing the changes that will happen over the next 12 months. (10–15 mins)

Main -

To explain the cause of seasons you will have to use a globe. Remind the pupils about the day and night cycle. Show them that the Earth rotates but it is tilted significantly. Place a lamp with no cover on a desk and the globe to one side of it with the pole angles towards the lamp direction. Make sure that the centre of the lamp is at the same height as the centre of the globe. The globe will be in the 'summer in the northern hemisphere' position northern hemisphere' position. Rotate the globe and show that the pole has sunlight for 24 hours each day while the South Pole is in permanent darkness. Describe how the length of the day varies with latitude, mentioning your current location. The 'Climate comparisons' activity will allow the pupils to find patterns in the weather conditions around the globe and should result in a greater understanding of the variation.

Now move on to look at the path the Sun takes across the sky during different seasons. The final 'High in the sky' activity is meant to be a planning activity, but it can be carried out if time is available.

Plenary - Seasonal eating?

Can the pupils match pictures of various locally produced foods with the seasons they are ready in? What do they think about the idea of flying in fresh food from around the world? Are there any problems with having 'seasonal' food available all year round? (5–10 mins)

Teaching suggestions

• **Special needs.** Provide a completed spreadsheet of weather statistics for the pupils to analyse. They should concentrate on looking for patterns and matching the data to locations on a map.

• **Extension.** The pupils could look at more detailed weather statistics to see if they can find any evidence of changes in the weather patterns. They need to find rainfall figures for the past 50 years for a few chosen locations and see if it increasing, decreasing or staying the same. Do they have enough evidence to say that weather patterns are changing due to global warming?

• **Learning styles**

Visual: Watching demonstrations and simulations of the seasons.

Auditory: Describing how the tilt of the Earth affects the seasons.

Kinaesthetic: Researching weather information.

Interpersonal: Consolidating information from different groups.

Intrapersonal: Interpreting information to find patterns.

• **Homework.** The research into changes in weather patterns can be done out of school hours.

• **Functional skills link-up. ICT**

Use appropriate techniques and design queries to locate and select relevant information (level 2).

Learning Outcomes

All pupils should be able to describe the length of the year in term of the Earth's orbit and the length of the day in terms of the Earth's rotation.

Most pupils should be able to describe the relationship between the length of a day, height of the Sun and the season.

Some pupils should also be able to explain the differences in the seasons in terms of the axial tilt of the Earth.

Additional teachers notes

Climate comparisons equipment and materials required: Access to the Internet and a spreadsheet.

High in the sky equipment and materials required per group: a lamp, protractor, light sensor and possibly a ball to represent the Earth. **Safety.** The lamps will become hot (using a low energy bulb will keep the temperature down).

Fusion 2: P1.11 – Eclipses

National Curriculum Link up

•3.1b. 3.4b.

Learning Objectives

Pupils should learn:

That a solar eclipse occurs when the Moon blocks out light from the Sun causing a region of the Earth to be in shadow.

That a lunar eclipse occurs when the Earth blocks the path of light to the Moon causing it to be in shadow.

How to use a model to explain observations.

Teaching / Learning activities

Lesson structure

Starter - Shadow

The pupils have to give a detailed description of how shadows form. This must include a ray diagram. What happens if the light source is large? [You get a partial shadow, 'penumbra' around the edge.] (10 mins)

Main -

Discuss the diagram showing how a solar eclipse happens and then let the pupils carry out the 'Modelling a solar eclipse' activity to confirm their ideas. The pupils then move on to looking at a lunar eclipse in the 'Modelling a lunar eclipse' activity.

Discuss the diagram from the pupil book and allow them to check the ideas with their simple models. This should be easy as the pupils tend to place the Moon quite close to the Earth and so it easily falls into shadow. Get one of the groups to show the rest of the class what they have found so that you can check their understanding.

Plenary - Seek me out

Give the pupils a word search with the key words from the topic. Don't provide a word list; instead give them a set of questions as clues to the hidden words. (5–10 mins)

Teaching suggestions

• **Special needs.** Provide some hint diagrams to hep the pupils set up their models.

• **Extension.** The arrangement of the Sun, Earth and Moon is not as simple as the models used in this topic may suggest.

If everything was in line, then there would be a total eclipse every month but we only get around three each year. The pupils can try to find a more detailed model or simulation that takes into account the details of the arrangement and the tilt of the Moon's orbit.

• **Learning styles**

Visual: Observing the changing phases of the Moon.

Auditory: Describing the behaviour of the Earth and Moon.

Kinaesthetic: Modelling the movement of the Moon around the Earth.

Interpersonal: Working in teams to model eclipses.

Intrapersonal: Evaluating their models.

• **Homework.** The pupils can find out where and when the next solar and lunar eclipses are. They can even work out how much it would cost to go and see them.

Learning Outcomes

All pupils should be able to state that an eclipse of the Sun occurs when the Moon obscures it and an eclipse of the Moon occurs when the Earth obscures the Sun.

Most pupils should be able to draw a simple diagram showing how a shadow is formed on the Earth during a total eclipse of the Sun.

Some pupils should also be able to explain why, during eclipses, the whole surface of the Moon can be in eclipse while only a small part of the Earth is in total shadow.

How Science Works

Describe how the use of a particular model or analogy supports an explanation (1.1a1).

Additional teachers notes

Modelling a solar eclipse equipment and materials required: An angle-poise lamp, ping-pong ball (Moon) and a ball around the size of a small football (Earth). (A round balloon can work as an alternative Earth.) The balls can be attached to cotton or supported on sticks so that the pupils can move them about. See CLEAPSS Guide L194 for light sources, etc. and PS17 for information on viewing eclipses. **Details.** This is very similar to the earlier experiments. The main difficulty will be in getting the lamp distance correct and the room dark enough to see a strong shadow on the surface of the Earth. **Safety.** Hot lamps (using a low energy bulb will keep the temperature down).

Modelling a lunar eclipse equipment and materials required: As above. **Details.** This time, the pupils will have an easy time getting the Moon to move into shadow. If they try a more realistic scale, the Moon being a few metres away from the Earth, they will have a bit more difficulty. **Safety.** Hot lamps (using a low energy bulb will keep the temperature down).