Unit 8K Light

About the unit

In this unit pupils:
- build on their knowledge of light and its effects
- learn how we see objects
- represent light as a ray and use this concept to explain reflection and refraction
- find out about the origin of coloured light and the appearance of coloured objects

In scientific enquiry pupils:
- consider why the spectrum described by Newton has seven colours
- make and test predictions about the path of light
- measure and record angles
- identify and make predictions from patterns in data
- investigate reflection and refraction at a plane surface
- investigate the effects of coloured light on the appearance of objects

Note

Much of this work involves the interpretation and analysis of visual information gathered from a variety of sources. Visually impaired pupils will be able to take part in activities through careful use of their residual vision and sense of touch, as many light sources are also heat sources. Teachers could adapt the work on colour to ensure that any pupils with impaired colour vision can make a contribution that is valued by the rest of the class.

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

This unit uses ideas developed in the key stage 2 programme of study. It builds on ideas introduced in unit 3F ‘Light and shadows’ and unit 6F ‘How we see things’ in the key stage 2 scheme of work.

Sound travel is compared to light in unit 8L ‘Sound and hearing’. The drawing of objects in different lighting conditions is covered in unit 8A ‘Objects and viewpoints’ in the art and design scheme of work.

Light as a wave is studied at key stage 4.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: make measurements of light intensity using a light sensor and compare the effects of materials on light; make predictions about the reflection of light at plane surfaces, measure angles with precision and make generalisations from the data; frame a question about light and colour and plan how to investigate it

some pupils will not have made so much progress and will: classify materials as opaque, transparent, translucent, reflectors or absorbers, on the basis of data from light sensors or visually; identify patterns in angular measurements of reflected rays of light; with help, investigate a question about colour and light

some pupils will have progressed further and will: draw conclusions from their data, informed by scientific understanding about reflection and refraction of light at plane surfaces; make predictions about image formation using the law of reflection or the patterns of behaviour from refraction; make sufficient observations when investigating colour to draw valid conclusions

in terms of physical processes

most pupils will: recognise that light travels in straight lines at very high speed; represent the path of light by rays; describe how light is reflected and refracted at plane surfaces; explain the origin of colour in the dispersion of white light and describe the effects of coloured filters and different coloured lights on the appearance of coloured objects; give an example of how colour is important in everyday life

some pupils will not have made so much progress and will: describe how light is reflected at plane surfaces and describe reflected images; describe the effect of a prism on white light and recognise that filters and coloured objects absorb some colours and transmit or reflect others

some pupils will have progressed further and will: calculate the time for light to travel, *eg from the Sun*; explain the appearance of coloured objects in coloured lights

Prior learning

It is helpful if pupils:

- know that light travels from a source
- can distinguish between opaque, transparent and translucent materials and relate shadow formation to opaque materials
- know that light is reflected from shiny surfaces
- know that we see things only when light from them enters our eyes

Health and safety

Risk assessments are required for any hazardous activity. In this unit:

- a laser may be used to demonstrate how light travels
- pupils use ray boxes

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly words:

- relating to the behaviour of light and its interaction with materials, *eg transparent, opaque, spectrum, reflection, refraction*
- with similar but distinct meanings in everyday use, *eg image, reflection*

Resources

Resources include:

- pictures showing luminous and non-luminous objects
- secondary sources to find out about optical devices and phenomena, including reference books and CD-ROMs
- software simulation of colour mixing
- datalogger and light sensor
- a range of glass blocks of different shapes
- coloured filters and objects
- laser (class 2)
- infrared remote control device, *eg from audiovisual (AV) equipment*

Out-of-school learning

Pupils could:

- look for reflective materials in different situations, *eg on road signs, safety clothing*
- think about how an infrared remote control device for a TV works
- observe the effects of coloured lighting in shops, in theatres and on TV

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How does light travel?			
• that light travels from a source • that light travels at a very high speed, much faster than sound	• Review pupils' understanding of light by asking them *Where is there light in this room?* Help them to develop the idea of light travelling and to recognise that although, when a light is switched on, its effects on objects seem instantaneous, this is because light travels at immense speed. Recall their experience of thunder and lightning, to show that light travels much faster than sound. • Ask pupils for suggestions on how we could show that light moves, *eg how a lighthouse works.* Help pupils to carry out a thought experiment. Ask them to imagine what would happen if the source were moved further and further away from an object, and help them to understand that, at great distances, there is a lapse of time between leaving one and meeting the other. Some will have heard of the speed of light. Help them towards an understanding of this very large number by relating it to everyday speeds and distances, and comparing these with the distance between stars.	• recognise that light is all around • state that light travels much faster than sound	• Some pupils respond to the question *Where is there light in this room?* by identifying light sources rather than the idea that light is all around. Recognition that light radiates from a source implies that it is moving. Some pupils may believe that this movement of light applies only to very strong sources, *eg the Sun*, and that light from a weak source, *eg a torch bulb,* is different and slower. • The speed of light is 300,000 km/s, and it thus takes light from the Sun 8.5 minutes to reach Earth, and reflected light from the Moon 1.3 seconds. Light from the nearest star (other than the Sun) takes 4 years to reach us. • In unit 7L 'The solar system and beyond' pupils will have considered the solar system and stars. They will not have considered distances in terms of light.
• to interpret evidence and draw conclusions from it • that light travels in a straight line • that the path of light can be represented by rays	• Carry out a range of quick activities designed to develop the idea that light travels in straight lines, *eg producing a shadow from a strong source, trying to look down a piece of rubber tubing, showing images of light rays shining through clouds, light rays in a mist, spotlight beams, light beams being reflected in a mirror.* Encourage pupils to try to explain these phenomena in terms of a sequence beginning with light leaving the source and finally hitting a screen. Help pupils to use the idea of light travelling in straight lines in their explanation. • Demonstrate how we can test the idea by shining a beam of light through a series of holes in pieces of card arranged one behind the other. Reinforce this concept by showing a laser beam and sprinkling talc or chalk dust in its path. • Introduce the use of rays to represent light and ask pupils to draw diagrams of the evidence they have seen, using such lines to show the path taken by light in each case.	• describe evidence to support the idea that light travels in a straight line • represent simply the path of light as rays	• In key stage 2 pupils will have explored rays and beams of light. They are less likely to have produced explanations for phenomena in terms of light travelling in straight lines, or to have constructed ray diagrams. ⚠ **Safety** – lasers should be class 2 and obtained from a reputable supplier. Laser pointers are usually class 3 and so are unsuitable

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What happens when light meets an object?			
• that materials may be transparent, translucent or opaque • to use ICT to make measurements • that light may be absorbed, transmitted or reflected when it hits an object	• Provide a range of materials for pupils to sort into transparent, translucent or opaque groups, by shining light from a ray box onto them. Ask them to explain what is happening to the light in each case, and introduce the ideas of reflection, transmission and absorption. • Extend this work by allowing pupils to use a light sensor with a datalogger to compare the amount of light that is reflected by or transmitted through the different materials. • Establish that materials reflect or transmit different amounts of light and ask pupils to suggest what has happened to the rest of the light, developing the idea of absorption.	• use words precisely when describing the effects of materials, *eg transparent, translucent, opaque, reflect, absorb* • use a light sensor to make comparisons • explain that some light may be absorbed when it hits an object	• Pupils will have carried out similar work during key stage 2, but this work provides a useful opportunity for pupils to use ICT and to introduce the concepts of reflection, transmission and absorption, which will be developed in other activities. • Draw attention to materials that both reflect and transmit light. • Extension: pupils could find out how bar-code readers work. ⚠ **Safety** – if school-produced ray boxes are used, they must be checked for electrical safety by a Portable Appliance Test
How do we see things?			
• that we see non-luminous objects because light is reflected from them and enters our eyes • to represent the path of light by rays	• Elicit pupils' ideas about how we see things. Use their views to develop the idea that light travels into our eyes from luminous objects for us to see things. Extend this to non-luminous objects. • Provide pupils with a picture containing luminous and non-luminous objects, and ask them to draw in some of the light rays that enable us to see these objects.	• explain how non-luminous objects are seen, using words, *eg 'because light is reflected from them and enters our eyes'*, and ray diagrams	• At key stage 2 pupils are likely to have carried out activities illustrating that they see light sources when light from them enters the eyes. However, pupils may retain an 'active eye' model of seeing and draw rays travelling from the eye towards the seen object. • Encourage pupils to represent the path of light as a single ray. • Extension: pupils could imagine people in a mirrored room, *eg dance studio/gym,* and draw lines to show how objects can be seen both directly and by reflection.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How do mirrors reflect light?			
• that light is reflected from plane surfaces in a predictable way • to make accurate measurements • to represent data graphically and draw a line of best fit • to draw a conclusion from data and to say whether it matches their prediction	• Introduce reflection using a torch in a darkened room. Ask pupils to predict where reflected rays will go. • Demonstrate the use of a ray box and slit to produce a thin beam of light. Ask pupils to predict what will happen if the beam shines onto a plane mirror, to record their prediction, and to plan how to investigate their predictions of reflections at such a surface. Point out the need for accurate measurement and show them how to measure angles of light rays with reference to the normal, using a protractor, and to draw a line graph of their results. Through questioning, establish whether the data collected supports the pupils' predictions. • Ask pupils to find out how infrared remote-control devices work and whether infrared is reflected in a similar way to light.	• make predictions about the way that light is reflected from plane surfaces • make and record accurate measurements of angles of incidence and reflection with respect to the normal • represent the data as a line graph and draw a line of best fit • make a generalisation, *eg the light is reflected from a plane surface at the same angle at which it hits it*	• These activities provide a good opportunity for making, testing and refining predictions in a simple situation. • At key stage 2 pupils are likely to have investigated reflection by mirrors, but they will not have drawn ray diagrams and measured angles.
How are images formed?			
• that when light is reflected from plane surfaces an image is formed • to make and test predictions about reflections • to make and test predictions about the number of images formed in paired mirrors	• Introduce the idea of the nature of a 'mirror image' produced in a plane mirror. Ask pupils how such an image differs from the object viewed, and explore their explanations of why this happens, *eg pupils could, in pairs, model object and image in a mirror.* • Ask pupils to explore the symmetry of images by predicting and testing which capital letters or words are symmetrical and by predicting the number of images formed of an object placed between two plane mirrors set at different angles. Encourage pattern seeking so that pupils can make predictions. Show how to 'see yourself as others see you' in two mirrors set at 90° to each other.	• describe the nature of the image formed in a plane mirror, *eg inverted* • suggest how such an image is formed • make and test predictions about the number of images formed in mirrors • record findings, describing patterns in these	• Although the mirror image appears to be laterally inverted, this presents the problem of why it is not inverted top to bottom as well. It would be more accurate to say the mirror inverts 'back to front'. This can be demonstrated by writing on an overhead transparency (OHT), holding it in front of a mirror and looking through it at its reflection. • The relationship of the angle between the mirrors (A) to the number of images (N) is expressed as $A(N+1) = 360$. It is helpful to suggest that pupils initially investigate angles that are factors of 360.
Checking progress			
• to apply understanding of reflection to everyday situations	• Present pupils with a range of examples of how reflections are used and ask for explanations of how they work, *eg reflective cycle clothing, reversed ambulance signs, kaleidoscope, periscope, Pepper's ghost*.	• explain everyday reflections using words and/or ray diagrams	• CD-ROMs and internet sites provide useful support for these aspects of light/optics. The kaleidoscope was invented by the Scottish physicist David Brewster as a design aid. • Extension: pupils could practise drawing in a mirror, *eg following the shape of a star, looking only in a mirror.*

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Can light be bent?			
• that light changes direction at a boundary between two different media • to identify patterns in observations • to apply understanding of refraction to everyday situations	• Demonstrate simple situations involving refraction, *eg pencil in beaker of water appears to bend,* and the strange views perceived when looking through water, *eg in a swimming pool.* Introduce the idea of light changing direction when it passes from one transparent medium to another, and the term 'refraction', and distinguish this from reflection. Help pupils to interpret what they see by explaining that they imagine light as having travelled in a straight line rather than as having been refracted (bent). • Provide a range of glass or perspex blocks of different shapes, including rectangular and semicircular, and ask pupils to investigate their effects on a single ray of light produced by a ray box. Ask them to look for patterns in their observations of reflection when changing the angle of incidence. Establish generalisations from patterns of observations. • Set up the 'disappearing coin in a cup of water' demonstration. Ask pupils to explain how it works.	• make generalisations from their observations of refraction, *eg that a change of direction occurs only at an interface; light bends towards the normal (inwards) when travelling from a more dense to a less dense medium, and vice versa* • draw selected angles of incidence and refraction and use these to establish generalisations, e*g when the ray travels from air to glass, the angle of refraction is smaller than the angle of incidence* • draw a ray diagram to explain a phenomenon of refraction	• Aboriginal peoples learn to compensate for refraction when spearing fish. • Pupils may need help if they try to draw ray diagrams illustrating refraction. • At this stage, it is sufficient to establish the idea of refraction. Snell's law is not required, so it is best to avoid measuring, as pupils will look for a numerical relationship (and find unhelpful ones).
What is a spectrum?			
• that white light can be dispersed to give a range of different colours • why the spectrum has seven colours • to use scientific knowledge to suggest reasons for physical phenomena	• Demonstrate how white light can produce a spectrum when shone through a prism, and describe the work of Isaac Newton in this field. Ask questions about colours, *eg Can you really see seven colours?* • Provide pupils with prisms and ask them to explore and record the images they see in them. • Allow pupils to make their own spectrum and challenge them to suggest how the coloured rays could be remixed. Help them to achieve this, using a second prism, and develop the idea that white light consists of a mixture of different coloured lights, which can be separated and combined.	• identify the colours of the spectrum • describe how white light is dispersed by a prism to give a range of different colours • describe how a spectrum can be recombined to form white light	• Most people cannot distinguish indigo in the spectrum, and it is thought that Newton included this because of his belief in the mystical significance of the number seven. • Extension: ask pupils to find out how a rainbow is formed.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How can we change colour?			
• how coloured filters change white light • to combine knowledge from different sources to explain how coloured filters work • how coloured light can be combined to produce new colours	• Ask pupils to explore how coloured filters affect light, *eg by producing a spectrum and allowing this to pass through filters of different colours; by passing white light through one filter and then through a second filter.* • Remind pupils of their earlier work on absorption and transmission of light, and on the nature of coloured light as demonstrated by the spectrum. Ask pupils to explain why light appears to change colour as it passes through. • Establish the idea that coloured filters will only transmit light of certain colours, the other colours being absorbed, and help pupils illustrate this with annotated diagrams. • Demonstrate, using an overhead projector (OHP), software or video clips, how the primary colours of light can be combined to produce white light, and briefly discuss the relevance of colour vision and the production of coloured pictures on television.	• investigate how coloured filters change white light • suggest how filters affect white light • investigate how coloured light can be combined to produce new colours	• Detailed understanding of colour vision is not required here. • Most filters allow a mix of colours to pass through and results are often unconvincing. Have a set of primary colour filters on hand for demonstrations, ie spectral blue, green and red. • In unit 8A 'Objects and viewpoints' in the art and design scheme of work pupils draw objects using different light sources and viewpoints.
• how coloured objects appear in white light and in different colours of light • to use scientific knowledge and understanding to explain observations	• Ask pupils to investigate the effects of viewing different coloured objects in beams of light of different colours. They should collect a range of observations as a table, and try to find patterns in these. Ask pupils about applications of this effect, *eg in disco lighting, in matching dyes in fabrics, in identifying colour of clothing under street lighting.*	• investigate how coloured objects appear in white light and in different colours of light • identify and explain patterns of their observations using appropriate vocabulary, *eg reflect, absorb, transmit*	• This activity is best carried out with objects in an enclosed box with a hole for viewing, to eliminate as much extraneous light as possible. Software simulations may provide more convincing 'results'.
Reviewing work			
• to describe what happens to a beam of light when it encounters a range of materials • to use scientific knowledge and understanding to plan and to explain the reasons for their plan	• Provide pictures of a series of mirrors, opaque materials and transparent blocks and ask pupils to complete the paths of a light ray incident on them. • Ask pupils to design the lighting for a theatre production in which particular colour effects are desired, and to present their suggestions to the group or whole class. • Ask pupils to describe and explain any optical effect that has particularly impressed them, *eg laser display*.	• describe, using annotated diagrams and the correct scientific terminology, how the path of light can be altered by reflection or refraction • present an account of the use of colour in creating particular effects	

