Science@School | Book 3F

Light and shadows

Teacher's Guide

Support material for the pupil book
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Teacher's sheet: comprehension

See **pages 4 and 5** of *Light and shadows*

Answers

1. **The beam should spread out in front of the torch. Its edges should have straight lines. The beam should shine on the mouse.**
2. **It lets us see.**
3. **The light must be strong. The light source must be big. The light source must be close.**
4. **You may be dazzled.**
5. **The Sun.**
6. **Daylight. If you look at the light from a torch bulb in daylight, the light is hard to see.**

Complementary work

The children can use secondary sources to find out information about the Sun and about other stars.

Teaching notes

It is important, at the beginning of this unit, to assess the children's knowledge of light from previous work. In the introduction on page 8, it is suggested that you approach this by considering sunlight first, as this is the title of the unit. You may prefer to look at the children's knowledge of the properties of light first, such as the fact that light does not pass through opaque objects but can pass through translucent and transparent objects in varying amounts.

It used to be thought that the Sun was burning away in space, like a large lump of coal, but this is not the case. The Sun is a huge ball of gas. It has a force of gravity which pulls everything towards it, just like the force of gravity does on the Earth. However, the Sun's gravity is much more powerful, as it is a million times larger than the Earth. This great force squashes the gases together. In the centre of the Sun, hydrogen gas is squashed so hard that it changes into helium gas (this is the gas which makes party balloons rise). This change releases energy as heat and sunlight.

The children may have come across the idea of light as a form of energy if they have studied the growth of plants.

Teacher's sheet: activity

Based on **pages 4 and 5** of *Light and shadows*

Introducing the activity

(a) This activity should be done after the children have read pages 4 and 5 in the pupil book. You may like to refer to the requirements for a bright light on page 4 of the pupil book to help the children think about how they could compare torches. If the torches in the collection differ in size, you may like the children to predict which ones they think will be the brightest and dimmest before they carry out the investigation.

Using the sheet

(b) Give out the sheet, let the children fill in their names and form, then go through task 1 and let the children try it (see note (i)).

(c) Go through task 2, then let the children try it (see note (ii)).

(d) Let the children try task 3.

(e) Go through task 4, then let the children try it.

(f) Go through task 5, then let the children try it.

Completing the activity

(g) Let the children compare their results (see note (iii)).

(h) If you asked the children to make predictions before the activity, you could now ask them to compare their predictions with their results.

Conclusion

The brightness of torches can be compared by making a fair test. The distance between the torch and the object it is shining on must be the same for all torches in the test. The comparison of brightness is made simply by judging which is the brightest and the dimmest.

The brightest light will send out the strongest light from its bulb and may have the largest reflector. The dimmest light may have a large bulb and reflector but have batteries which have almost run out of power.

Teaching notes

(i) You may like the children to bring in torches from home or provide a selection of torches used in school or by colleagues.

(ii) The children could suggest putting the torches at one end of a dark room and looking at how they shine towards an observer. They could also suggest shining each torch onto a white card and see which one makes the card look the brightest. In any test, the distance between the torch and the object it is shining on should be the same for all torches.

(iii) Draw the children's attention to the fact that they have not measured the light with any standard units. You may like to tell them that there are light meters which measure the amount of light in units called lux. You may be able to obtain one and demonstrate it.

Teacher's sheet: comprehension

See **pages 6 and 7** of *Light and shadows*

Answers

1. **Sunlight, electric light, candlelight, firelight.**
2. **The Sun.**
3. **By people burning wood or dried grasses.**
4. **A bundle of reeds.**
5. **The wick.**
6. **(i) Gas light and electric light.**

   (ii) They were so bright that people were able to read or work at night.

Complementary work

The children can use secondary sources to find out about indoor lighting in Tudor and Victorian times.

Teaching notes

The children should realise that light is given out from certain objects called light sources. When they realise this, they will also realise that most objects are not light sources and may wonder how it is that they can still be seen. You should point out that when light spreads out from a source, it strikes other surfaces and is reflected from them. Most objects in our surroundings are visible because of the light that is reflected from them.

At this stage, you may wish to introduce the idea that we can see because of the light that enters the eye. Sometimes people have the notion that rays pass out from the eyes to let us see. If that were true then we would be able to see in the dark.

The children may ask why objects are different colours. You may like to respond by showing them a picture of light passing through a prism to give the spectrum of red, orange, yellow, green, blue, indigo and violet. White light is really made up of all these colours. You can tell the children that rain drops also sometimes act like prisms to produce a rainbow. When light strikes a surface, some of the colours are absorbed and some are reflected. We see the colours that are reflected. Two or more colours may be reflected to give different shades of colours.

You may also like to link the use of lights to the consumption of energy and trends in global warming. This information could then be used in a 'switch it off' campaign.

Teacher's sheet: activity

Based on **pages 6 and 7** of *Light and shadows*

Introducing the activity

(a) Use this activity after the children have studied pages 6 and 7 in the pupil book. Tell the children that they are going to make a survey about the types of lights in some of the rooms in their homes (see note (i)).

Using the sheet

(b) Give out the sheet, let the children fill in their names and form, then go through task 1 and let the children try it (see note (ii)).

(c) Go through task 2, then let the children try it (see note (iii)).

(d) Go through task 3, then let the children try it (see note (iv)).

(e) Go through tasks 4 and 5, then let the children try them.

Completing the activity

(f) You could ask the children to collate their results so that the most frequently used light source and the most frequently used position of light source could be identified. This could be used as an ICT activity.

(g) Tell the children that when scientists complete their work, they look at it again to see if it could be improved. Ask the children how they think the survey could be improved (see note (v)).

Conclusion

Although the results will depend on the home sampled, it may be found that the ceiling is the most widely used position for a light source, and that fluorescent lights are used in the kitchen. Some kitchens may also have clear strip lights, clear and pearl bulbs may be used in living rooms and bedrooms and candles may be present in some living rooms and bedrooms.

Teaching notes

(i) Any comparison of home circumstances should be treated with sensitivity. To reduce problems of this kind, just three rooms, found in almost all homes, are used in this survey.

(ii) You may like to tell the children that objects which give out light are called sources of light. At this point, do not distinguish between objects which give out light to see by from objects like televisions or computers which give out light as part of their function.

(iii) At this point, do not mention lights which may be found on shelves or windowsills.

(iv) It may be helpful to show the children a clear light, a pearl bulb and a clear strip light which has a filament (often used in concealed lighting in kitchens).

(v) The children may point out that candles may be placed on windowsills or mantelpieces and that lamps, such as an electric lamp may be on a shelf or on the floor.

Children may also ask if televisions or computers should be included, as they are also light sources.

Teacher's sheet: comprehension

See **pages 8 and 9** of *Light and shadows*

Answers

1. **A = New York, USA; B = London, UK; C = Tokyo, Japan; D = Sydney, Australia.**
2. **The Moon.**
3. **At a football stadium.**
4. **Because street lighting is really not very bright.**
5. **Because the cost of bright lighting is high.**
6. **(i) Look at a picture of the world at night taken from space;**
   (ii) There would be bright lights round the cities, but the countryside and oceans would be dark.

Complementary work

You could show the children the lighting-up times in a newspaper and make a collection of them over a month to show the children how they change. You could relate this to the times of sunrise and sunset, taken from a diary, and also relate this to the seasons of the year. This work could be linked to Unit 8.

Teaching notes

Although the Moon appears to glow in the sky it is not a light source. Sunlight strikes the surface of the Moon and is reflected towards the Earth. As the Moon moves in its orbit around the Earth, it presents a different illuminated surface to the Earth each day. At a full Moon, all the light shining on the Moon from the Sun is directed towards the Earth and we see a white disc. At other times, only part of the illuminated surface is seen – the same amount of Moon is always facing into space. At these times we see shapes such as a crescent, half moon or a shape between a half and full Moon called a gibbous Moon. These shapes of the illuminated Moon are called the phases of the Moon. They are not made by a shadow of the Earth being cast on the Moon.

Stars are also light sources in the night sky. They are made of hydrogen and helium like the Sun (see the notes to Unit 1) and produce light in the same way as the Sun.

As the Earth moves in its orbit round the Sun, each hemisphere tips towards the Sun when it is summer there and tips away from it when it is winter there. These changes in the way a hemisphere tips towards the Sun affect the time of sunrise and sunset and, in turn, affect the lighting-up times. The time for which outdoor lighting is switched on can be related to the position of the Earth in its orbit.

Teacher's sheet: activity

Based on **pages 8 and 9** of *Light and shadows*

Introducing the activity

(a) You may like to use this activity straight after the introduction on page 10 of this *Teacher's Guide*, or after the children have studied pages 8 and 9 in the pupil book. Tell the children that they are going to make their own plan and their own table in this investigation, and look for a pattern in the results.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 and let the children try it (see note (i)).

(c) Go through task 2, then let the children try it (see note (ii)).

(d) Let the children try task 3 (see note (iii)).

(e) Let the children try tasks 4 to 6.

Completing the activity

(f) Let the children compare their results (see note (iv)).

(g) Ask the children if they noticed anything else about how the light changed as the torch was raised higher and higher (see note (v)).

Conclusion

The smallest area of the table was lit up when the torch was closest to the table. The largest area of the table was lit when the torch was at its highest point above the table.

As the distance between the table and torch increased, the width of the illuminated area of the table also increased.

Teaching notes

(i) The plan should show that the torch will be held at different distances above the table. At each distance, the height of the torch and the diameter, or width, of the light beam will be measured.

(ii) The table should have two columns headed: 'Height of torch (cm)' and 'Width of light beam (cm)'.

(iii) When the children are trying the investigation, look for them trying to keep the height of the torch steady while they make their measurements.

(iv) You may like the children to make bar charts of their results.

(v) They should notice that a small area was very brightly lit and a large area was more dimly lit. This is due to the same amount of light having to cover a larger area. You could also point out that when scientists are performing an investigation, they keep a look out for other things besides what they are making their main observations on.

Teacher's sheet: comprehension

See **pages 10 and 11** of *Light and shadows*

Answers

1. **Rays of light should be drawn from the slits down to the bottom of the picture. They should be straight.**
2. **The headlamp.**
3. **The road.**
4. **(i) Fog and mist; (ii) Tiny droplets of water; (iii) The beam of light cannot be seen travelling from the headlamp. Only the light source and where the light lands can be seen.**

Complementary work

(a) The children could use secondary sources to find out about lighthouses and how they make their light beams.

(b) Fill a large, globular wine glass with water, add two or three drops of milk and stir it in. Shine a torch at the wine glass and observe the beam of light shining through the slightly grey, milky water. If some children have a suitable attitiude and ability, they could demonstrate this experiment to the rest of the class.

Teaching notes

Light is usually invisible when it shines through the air. We may see the light source and the objects which reflect the light, but we rarely see the passage of light from source to object. In certain circumstances light beams can be seen.

Sometimes a beam of sunlight can be seen shining through a gap in the curtains. The beam can be seen in the room due to the dust in the air. Part of the light is reflected off the dust and into our eyes. In a similar way, sunbeams can sometimes be seen shining down to the ground through gaps in clouds. This is also due to dust particles in the air.

When a car headlight shines into fog or mist, the beam can be seen clearly due to the reflection of the light off the water particles. You can point out that the light beam does not travel far because the light is being reflected away by the particles.

The children may wonder how a torch or headlamp can make a light beam. In both these devices, a light bulb is surrounded by a curved surface. When the light is reflected from this curved surface, it travels in parallel rays of light, like the light passing through the slits on page 10 of the pupil book and in the activity in this unit.

Teacher's sheet: activity

Based on **pages 10 and 11** of *Light and shadows*

Introducing the activity

(a) You may like to use this activity either after the introduction on page 10 of this *Teacher's Guide* or after the children have read about beams of light on pages 10 and 11 of the pupil book. If you use it after the introduction on page 10, you may like the children to think about how they could make a small beam of light. If you use it after the children have studied the pupil book, you may like to tell them that scientists often perform experiments to confirm what they have read and that they are basing their experiments on the picture of light rays on page 11.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, go through task 1, then let the children try it (see note (i)).

(c) Go through tasks 2 and 3, then let the children try them.

(d) Go through tasks 4 and 5, then let the children try them.

(e) Go through task 6, then let the children try it (see note (ii)).

(f) Go through task 7, then let the children try it.

(g) Go through task 8, then let the children try it (see note (iii)).

Completing the activity

(h) Let the children compare their results.

(i) Ask the children to predict what might happen if they shone a torch through a comb. Ask them to try it and compare the result with their prediction.

Conclusion

When light shines through a slit it forms a straight-sided light ray which moves across the paper.

When a light ray strikes a solid object it is stopped, there is no light ray on the other side of the object.

Teaching notes

(i) Depending on the ability and attitude of the children, you may have to provide them with slitted cards.

(ii) The children should make a drawing based on Diagram 2 but showing a card with two slits. The children should draw two light rays moving in parallel across the paper.

(iii) The children should make a drawing based on Diagram 2 but showing a card with two slits and an object in front of one slit.

The children should draw one light ray being stopped by the object, and the other light ray continuing across the paper.

Teacher's sheet: comprehension

See **pages 12 and 13** of *Light and shadows*

Answers

1 **(i) A; (ii) A shadow.**

2. **The Sun, a torch, a headlamp, a street light.**

3. **It travels in straight lines.**

4. **(i) It has been blocked; (ii) The side on which the sunlight is not shining.**

5. **Go round the other side of the tree and look at it with their back to the Sun.**

Complementary work

The children could walk around the school on a sunny day and identify shady areas. You may also like them to look for signs of plant and animal life in shady and well-lit areas, to prepare them for work on the study of habitats.

Teaching notes

The work here supports the idea that light travels in straight lines. If a light could curve easily, it would flow round an opaque object like water flows around a rock in a stream, and there would be no shadow on the unlit side of the object. The fact that shadows have very clear edges which match the edges of the objects that produce them suggests that light does travel in straight lines. Light striking the surface of an opaque object is blocked, while light which just grazes the edges of the object continues in a straight line until it reaches another surface, and then forms the sharp edges of a shadow.

The children may ask why some objects let light through while others do not. You could tell the children that tissue paper is made by fibres which have holes between them and the light shines into the holes and is then reflected off the surfaces of the fibres in all directions. You could then tell the children that some materials are made of much smaller particles, which are packed together in a special way so that they have lots of 'holes' through which the light can pass. These objects are transparent (see Unit 10). The particles are so small that they can only be seen by very powerful microscopes. You may talk about these particles when you study materials in the curriculum.

Teacher's sheet: activity

Based on **pages 12 and 13** of *Light and shadows*

Introducing the activity

(a) Use this activity after the children have studied pages 12 and 13 in the pupil book.

Using the sheet

(b) Give out the sheet, let the children fill in their names and form. Go through task 1, then let the children try it (see note (i)).

(c) Go through task 2.

(d) Let the children try task 2.

(e) Go through task 3, then let the children try it.

(f) Go through task 4, then let the children try it (see note (ii)).

(g) Let the children try task 5.

(h) Let the children try task 6 (see note (iii)).

Completing the activity

(i) Let the children compare their results.

Conclusion

When light shines on solid objects a dark shadow is cast.

The shape and size of a shadow of an object changes as the position of the light shining on it is changed.

Teaching notes

(i) You may like the children to bring in some objects from home. Make sure the objects are complex, such as trucks and dolls, to show the best contrast between light and shadow.

(ii) The plan should show that the light will be shone on different sides of the object. It may also show that the light will be shone from different angles – for example, overhead, along the table top.

(iii) The children can record in words or in pictures. Most children may find it easier to record in pictures.

Teacher's sheet: comprehension

See **pages 14 and 15** of *Light and shadows*

Answers

1. **The shadow should be the same shape as the object, have sharp edges and be larger.**
2. **Because it makes a narrow beam of light.**
3. **On a wall or a screen.**
4. **The shadow would become larger.**
5. **The shadow would become smaller.**
6. **(i) Cutout models; (ii) The shadow changes shape to match it.**

Complementary work

(a) The children can use secondary sources to find out about the use of shadow puppets and shadow plays.

(b) The children can make their own shadow puppets and shadow plays using a screen, lamp and cardboard cutout models they have made themselves.

Teaching notes

This unit builds on the previous one by challenging the children to look more closely at shadow formation.

Up to this point, the children may think that a shadow is always the same size, although from films and cartoons they may be aware that shadows can be much larger than the objects that cast them.

It is important to let the children see how moving an object about in front of a lamp can alter its shadow and to find a relationship, such as the nearer the object to the lamp the larger the shadow. It should then be emphasised that, in science, an observation such as the one just made is then investigated more closely by taking measurements.

Shadow puppets are made and used in shadow plays in Java.

Teacher's sheet: activity

Based on **pages 14 and 15** of *Light and shadows*

Introducing the activity

(a) If you have used either of the two activities suggested in the introduction to this unit on page 11, you may like to use this activity straight afterwards. You could ask the children if they noticed how they could change the size of the shadow, and look for an answer about changing the distance of the object from the light and the screen. Tell the children that they are now going to investigate this observation in greater detail.

Alternatively, you could use this activity after the children have studied the unit on pages 14 and 15 of the pupil book, and use the activity to confirm what the children have learned.

Using the sheet

(b) Give the children the sheet, let them write their names and form on it, then go through task 1 (see note (i)).

(c) Let the children try task 1.

(d) Go through task 2, then let the children try it (see note (ii)).

(e) Go through task 3, then let the children try it.

(f) Go through task 4, then let the children try it.

(g) Let the children try task 5 (see note (iii)).

(h) Go through task 6, then let the children try it (see note (iv)).

(i) Let the children try task 7.

Completing the activity

(j) Let the children compare their results.

(k) Challenge the children to predict what might happen if they moved the screen back while keeping the object in the same place. Let the children test their predictions.

Conclusion

When the object moves further away from the torch, the width of the shadow on the screen becomes smaller.

The width of the shadow never becomes smaller than the width of the object.

When the object is kept in place, and the screen is moved further back, the width of the shadow increases.

Teaching notes

(i) You may ask the children to bring in torches and objects from home for this activity. The object must have a dimension to its shadow that can be easily measured (not a wavy outline).

(ii) Some children may need help with relating the diagram to their experimental set-up, and identifying distance A.

(iii) Let the children choose how many measurements they wish to make. You can point out later that the activities with the most measurements are more reliable because they give a clearer picture of how the shadow changed when the distance between the torch and object was changed.

(iv) The distance between the torch and object should be on the X axis, and the width of the shadow should be on the Y axis.

Teacher's sheet: comprehension

See **pages 16 and 17** of *Light and shadows*

Answers

1. **A.**
2. **The shadow of A would stay the same but the shadows of the others would become longer.**
3. **It always faces away from the light.**
4. **At your feet.**
5. **It gets longer.**
6. **It would change direction. It would change shape to match the changes in shape of your body as your body moved.**

Complementary work

A table lamp could be set up in the classroom and the children could move around it to see how their shadows change direction and move from one wall to another.

Teaching notes

Having gradually built up ideas about shadows in this, and the two previous units, you may find it useful to review the children's knowledge. If the children have spent some time in the past considering reflections, they may think that the shadow is a reflection of them on the ground. This is not the case. The shadow is dark because there is an absence of light. This is due to the light striking the object (the person) being blocked. A reflection is due to light bouncing off a very shiny surface.

The children may think that they can see features in a shadow, such as a face, as they can in a reflection. This is not the case. The shadow is dark and shows no features of the surface on which the light shines.

A shadow always matches the outline of the object. If the object changes shape, then so does the shadow. The shadow cannot have a different outline from that of the object, although the shadow may be longer or shorter than the object.

The light and the shadow of the object that is casting the shadow are on opposite sides. There is no gap between the base of the object and the shadow it casts.

7 Teacher's sheet: activity

Based on **pages 16 and 17** of *Light and shadows*

Introducing the activity

(a) If you have used the activity in the introduction to this unit on page 12 of this *Teacher's Guide*, you may like to follow it with this activity before the children study the unit in the pupil book. Alternatively, you may like to use this activity after the children have studied the unit in the pupil book to confirm what they have learned.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through tasks 1 and 2 (see note (i)).

(c) Let the children try tasks 1 and 2.

(d) Go through task 3, then let the children try it.

(e) Go through tasks 4 and 5 then let the children try them.

(f) Go through task 6 and let the children try it (see note (ii)).

(g) Let the children try tasks 7, 8 and 9.

(h) Let the children compare the predictions in task 7 with their answer in task 9 (see note (iii)).

Completing the activity

(i) Let the children compare their results.

Conclusion

When a light is shone on one side of an object, a shadow forms on the opposite side of the object. If the light is low down, the shadow is long. If the light is high up, the shadow is short.

When a light is raised from a low position to one directly over the object, the shadow changes from being long to being extremely short. When the light is directly overhead a shadow is not cast on the paper.

Teaching notes

(i) Give the children a blank sheet of paper on which to place the object. You may like to demonstrate how you can have the torch shining from different heights and from different directions. Make sure that the children realise they can move around the object to make their investigations.

(ii) You may have to rephrase this for some children to "What did you find out?"

(iii) The children should say that their prediction matched, partly matched or did not match the result, and describe how. They should not use phrases like "They were OK".

Teacher's sheet: comprehension

See **pages 18 and 19** of *Light and shadows*

Answers

1. **In A the Sun is low and on the left, and a long shadow is pointing in the opposite direction. In B, the Sun is above the tee and the shadow is short and points down the sheet. In C, the Sun is low and on the right, and a long shadow is pointing in the opposite direction.**

2. **It rises.**

3. **It goes down.**

4. **Place it upright on open ground, such as a lawn or sand pit.**

5. **(i) For telling the time; (ii) When the Sun is shining. The shadow cast by sunlight is used to tell the time. If the Sun is not shining, no shadow is cast and the sundial does not work.**

Complementary work

(a) The children could use secondary sources to find out about how the path of the Sun across the sky varies through the year. They could link this work to the complementary work in Unit 3.

(b) The children could use secondary sources to find out about the design of sundials.

Teaching notes

This unit links shadow formation with the turning of the Earth and the apparent movement of the Sun across the sky.

The children must be reminded that they must not look directly at the Sun, as this will cause damage to the eyes.

If the children have secure knowledge, from work in earlier units, of how the length and direction of a shadow varies with the position of a light source, you may wish to use it now to show them how it can be used to track the path of the Sun across the sky. In the morning, the long shadows pointing to the west indicate that the Sun is low in the eastern part of the sky. The short shadow at midday, pointing north in the Northern Hemisphere and south in the Southern Hemisphere, indicates that the Sun is high in the sky. In the afternoon, the long shadows pointing eastwards indicate that the Sun is low in the western sky.

If you have mentioned in Unit 3 how the Earth tips towards and away from the Sun as it moves in its orbit, you may like to remind the children of it again in this unit to provide a firm foundation for work in *5E Earth and beyond*.

Teacher's sheet: activity

Based on **pages 18 and 19** of *Light and shadows*

Introducing the activity

(a) You may like to use this activity after the children have studied pages 18 and 19 in the pupil book. You should begin by reminding the children that they should not look directly at the Sun in the sky. However, the path of the Sun across the sky can be investigated by studying the shadows that it makes (see note (i)).

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 with the children and let them try it (see note (ii)).

(c) Go through task 2, then let the children try it. (see note (iii)).

(d) Go through task 3, then let the children try it.

(e) Go through task 4 with the children, then let them try it (see note (iv)).

(f) Let the children try task 5.

(g) Go through task 6, then let the children try it.

(h) Let the children try task 7 (see note (v)).

(i) Go through tasks 8 and 9, then let the children try them (see note (vi)).

(j) Let the children try task 10.

Completing the activity

(k) Let the children compare their results.

Conclusion

The shadow points in the opposite direction to the position of the Sun in the sky. The Sun makes long shadows when it is low in the sky and short shadows when it is high in the sky.

Teaching notes

(i) The children have studied how the position of the light affects the shadow in the previous units. Here you can use the idea that the size and direction of the shadow can tell something about the light that is making the shadow.

(ii) You may like the children to look at the photograph of the shadow stick on page 19 while they begin the activity.

(iii) If the children have set up the shadow stick in a plant pot and put it on a Tarmac or flagged school playground, the shadow positions and predictions can be marked out in chalk. If the shadow stick is set up on grass, the shadow positions and predictions can be marked out with lines of sand. If the shadow stick is set up in a sand pit, the shadow positions and predictions can be marked out as shown in the photograph on page 19 of the pupil book.

(iv) The children do not need to write down any comparisons, but just judge the difference between the shadow and the prediction and use it to make a more accurate prediction of the shadow in the next hour.

(v) The children should make more accurate predictions as they become more familiar with the speed of the Sun across the sky.

(vi) Show the children a compass and use it to find the directions they need.

Teacher's sheet: comprehension

See **pages 20 and 21** of *Light and shadows*

Answers

1. **(i) The shadow should be to the right of the mug; (ii) The shadow should be to the right of the mug and come to a point; (iii) The lamps should be placed equidistant, at either side of the mug.**
2. **Whenever you have just one source of light.**
3. **When it is in the strong shadow cast by one room light.**
4. **(i) Use many lights; (ii) Operating theatre in a hospital.**
5. **Reflection.**
6. **The lighter the colour, the more it will bounce or reflect light. The darker the colour, the less light will be reflected.**

Complementary work

If the children have done the activity in Unit 2 they can use the results of the lighting survey to predict where dark shadows with sharp edges are found in the home, and where paler shadows with less-sharp edges are found. This provides an opportunity to show the children how data collected for one investigation can be useful in other ways.

Teaching notes

You can use this unit to remind children that darkness is an absence of light. When a shadow is cast, it is because there is an absence of light due to light being blocked by an object. If light then shines into the place where the shadow has formed, or is reflected from a shiny surface, the shadow will become paler and its edges will become less distinct. If enough light enters the space where the shadow has formed, the shadow can be eliminated.

While the children have been doing work on shadows they may have found that sometimes the shadow is very dark when the object is close to the surface on which the shadow has formed, yet when the object is moved towards the light source, the shadow becomes paler and may have a dark inner part and a paler outer part. These changes are due to the light source being large compared to the object. Light from the central part of the light source, such as the filament in a light bulb, forms the dark central part of the shadow, called the umbra. Light from other parts of the light bulb, such as the top and bottom of the light bulb, forms the paler outer part, called the penumbra. The children do not need to know about the details of the umbra and penumbra, but they may ask why the shadows change as they move objects about.

Teacher's sheet: activity

Based on **pages 20 and 21** of *Light and shadows*

Introducing the activity

(a) If you have used the introduction to this unit on page 13 of this *Teacher's Guide* you may like to use this activity straight afterwards, before the children study pages 20 and 21 in the pupil book. Alternatively, you may like to use this activity as an extension of the work on page 21. In either case, tell the children that you are challenging them to try and get rid of a shadow.

Using the sheet

(b) Give out the sheet and let the children write their names and form, then go through tasks 1 and 2 and let the children try them (see note (i)).

(c) Go through tasks 3 and 4, then let the children try them.

(d) Go through tasks 5 and 6, then let the children try them (see note (ii)).

(e) Let the children try tasks 7 and 8 (see note (iii)).

Completing the activity

(f) Let the children compare their results and explanations.

Conclusion

A dark shadow with sharp edges is produced when a torch shines on an object. A piece of white card reflects light from the torch back into the region where the shadow has formed. This makes the shadow much paler. When a mirror is used instead of a card, it reflects even more light and can cause the shadow to disappear.

Teaching notes

(i) You may wish to point out that the torch has got a bright piece of wire called a filament that produces the light yet many light bulbs have got a pearly surface which masks the filament and makes the bulb glow. Fluorescent lights produce light in a different way, but they also have a surface which gives a more diffuse glow.

(ii) You may like to remind the children about how smooth surfaces reflect light, and that a shadow is dark because there is an absence of light. They may use these facts when giving a reason for their prediction.

(iii) The children should say that the prediction matched, partly matched or did not match the result and why.

Teacher's sheet: comprehension

See **pages 22 and 23** of *Light and shadows*

Answers

1. **There should be two pictures. One showing a torch shining on the opaque block and making a dark shadow. The other picture should show the torch shining on the transparent block and making a weaker shadow.**
2. **Air, glass, water, certain kinds of plastic.**
3. **Greaseproof paper, thin materials on roller blinds, material from which a handkerchief is made.**
4. **Coloured wrapping paper, coloured glass.**
5. **Red light.**
6. **You could simply cover the light with green tissue paper; or make a cardboard framework and stick green tissue paper (or green transparent sweet wrappers) to it. When the light is switched on, only green light will pass through the tissue paper and make the light shine with a green light.**

Complementary work

The children could close their fingers over the front of the torch then switch it on. They should see that the light shines with a red glow. This is because the skin is translucent and the blood underneath absorbs all the colours in the light except red, which it lets pass through. In this activity, the blood is acting like a red filter.

Teaching notes

When light passes through a material, the path of the light ray changes. When a light ray strikes a surface at an angle and then moves through a transparent material and escapes again, the different colours in the light separate and form a spectrum.

When white light strikes an opaque object, some of the colours are absorbed, and some may be reflected. For example, a red apple absorbs all the colours in the spectrum and reflects red. If an object reflects all colours equally we see it as white. If an object absorbs all colours we see it as black.

When light passes through a filter, all the colours of the spectrum are absorbed except the colour of the filter. This colour then passes through the filter to shine on nearby objects. If the colour strikes an object which absorbs it, that object appears as black. A white object will reflect the colour. At this stage the children do not need to know details about how colours are reflected, but they may ask some questions which may be answered simply using some of the information here.

Teacher's sheet: activity

Based on **pages 22 and 23** of *Light and shadows*

Introducing the activity

(a) Remind the children that in certain circumstances white light splits up to show the different coloured light it is made from. Ask the children to name the colours of the rainbow and tell them that in part of this activity they are going to split light to show its different colours. Tell them that they are also going to make an investigation on one colour of light.

Using the sheet

(b) Give out the sheet and let the children fill in their names and form, then go through task 1 (see note (i)).

(c) Go through task 2 with the children, then let them try it.

(d) Go through tasks 3 to 5 and let the children try them (see notes (ii) and (iii)).

(e) Go through tasks 6 and 7, then let the children try them.

(f) Go through tasks 8 and 9, then let the children try them (see note (iv)).

Completing the activity

(g) Let the children compare their results.

Conclusion

When a narrow beam of light is shone into a glass of water at an angle to its surface, the light which emerges from the glass is split into the colours of the spectrum: red, orange, yellow, green, blue, indigo and violet.

When red light shines on a white surface it is reflected.

Teaching notes

(i) Depending on the attitude and ability of the children you may have to make the slits for them.

(ii) It is important for the experiment to be tried in a dark place so that the colours can be seen. Darken the room or use a room which can be darkened.

(iii) The children will have to move the torch around in the area shown by the arrows. They should look on the paper in region A and should see a small spectrum of colours. They may even see two spectra. The children could write about what they have seen, or draw a small spectrum from memory. It would be too difficult to hold the torch in place while a drawing was made. If you feel the children do not have the correct attitude or ability to use a glass container you could demonstrate this part of the activity.

(iv) The children should see that the pencil became paler due to the red pencil reflecting red light.