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# Cambridge Lower Secondary Science

## TEACHER'S RESOURCE 8

Mary Jones, Diane Fellowes-Freeman & Michael Smyth



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# Science

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# 6 Light

## Unit plan

| Topic | Learning hours | Learning content | Resources |
|---|---|---|---|
| 6.1 Reflections | 2 | The reflection of light from a plane surface, the law of reflection and drawing ray diagrams to show reflection of light. | **Learner's Book:** Questions 1–4<br>Activity 6.1.1: Mirrors and reflections<br>Think like a scientist: Measuring angles of incidence and reflection<br>**Workbook:** 6.1A Focus – Making reflections<br>6.1B Practice – Ray diagrams<br>6.1C Challenge – Accurate ray diagrams<br>**Teacher's resource:** Worksheet 6.1 Reflection in a plane mirror<br>Template 6.1: Results table and graph grid for *Think like a scientist: Measuring angles of incidence and reflection* |
| 6.2 Refraction | 2 | The refraction of light at the boundary between air and glass or air and water, how light changes speed when it passes between different substances and drawing ray diagrams to show how light is refracted. | **Learner's Book:** Questions 1–4<br>Activity 6.2.1: Refraction effects<br>Think like a scientist: Drawing accurate ray diagrams<br>**Workbook:** 6.2A Focus – Causes of refraction<br>6.2B Practice – Predicting refraction<br>6.2C Challenge – Refraction ray diagrams<br>**Teacher's resource:** Worksheet 6.2 Refraction in water and glass<br>Template 6.2A: Results table for *Think like a scientist: Drawing accurate ray diagrams*<br>Template 6.2B: Graph grid for *Think like a scientist: Drawing accurate ray diagrams* |





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| Topic | Learning hours | Learning content | Resources |
|---|---|---|---|
| 6.3 Making rainbows | 2 | White light is made from many colours, how dispersion of white light can be done with a prism and listing the colours of white light in the correct order. | **Learner's Book:** Questions 1–4<br>Think like a scientist: Making a rainbow<br>**Workbook:** 6.3A Focus – Colours of the rainbow<br>6.3B Practice – Making a spectrum 1<br>6.3C Challenge – Making a spectrum 2 |
| 6.4 Colours of light | 2 | What happens when colours of light are added, what happens when colours of light are subtracted and why we see different colours in terms of reflection. | **Learner's Book:** Questions 1–4<br>Activity 6.4.1: Making colours on the screen<br>Think like a scientist: Identify the colour<br>**Workbook:** 6.4A Focus – Adding primary colours<br>6.4B Practice – Subtracting colours of light<br>6.4C Challenge – Seeing colours<br>**Teacher's resource:** Worksheets 6.4A, 6.4B, 6.4C Coloured filters |
| 6.5 Galaxies | 2 | Galaxies contain dust, gas, stars and other solar systems. | **Learner's Book:** Questions 1–4<br>Think like a scientist: Estimating large numbers<br>**Workbook:** 3.5A Focus – Our own galaxy<br>3.5B Practice – Galaxies in space 1<br>3.5C Challenge – Galaxies in space 2 |
| 6.6 Rocks in space | 2 | Asteroids are rocks that are smaller than planets and scientists believe asteroids to be rocks left over from the formation of the Solar System | **Learner's Book:** Questions 1–4<br>Activity 1.1.1: Making a model asteroid<br>Think like a scientist: What happened at Tunguska?<br>**Workbook:** 6.6A Focus – Describing asteroids<br>6.6B Practice – Asteroids and planets 1<br>6.6C Challenge – Asteroids and planets 2 |
| Cross-unit resources | | | **Learner's Book:**<br>Check your Progress<br>**Project:** Investigating refraction<br>**Teacher' resource:**<br>**Language development worksheets**<br>6.1 Reflection and refraction vocabulary<br>6.2 Light word search<br>6.3 Correcting the answers |





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## BACKGROUND KNOWLEDGE

Learners will recall sources of light, such as the Sun and lamps. Light from these sources has been described as travelling in straight lines that can be represented in ray diagrams. The concept of reflection of light has been described in terms of how we see objects that are not sources of light. Learners should be familiar with plane mirrors and their uses in everyday life. Learners will also have seen some of the effects of refraction, such as not being able to see clearly through a glass of water or a rain-covered window. Learners may also have seen rainbows, caused either by rain or by water spraying from a hosepipe. Learners will also recall that light can pass through transparent objects.

## TEACHING SKILLS FOCUS

### Lesson starters

The lesson starter is the opportunity for the teacher immediately to engage and interest learners. The starter also informs learners what the lesson is about and gives them time to start thinking about this – possibly new – topic. More than this, it gives you a tool with which to assess prior understanding and possibly detect misconceptions in a much less formal way than just asking questions.

For example, in a lesson about reflection of coloured light, you could have various colours of construction bricks set out on a sheet of white paper. This could be positioned in one conspicuous place to be seen by learners as they arrive for the lesson, or several of could be placed on tables around the room. As learners arrive they may wonder what this is for, and this is a positive start. The use of a familiar object allows them to identify with that object and helps to break down the barrier that some learners imagine between the science laboratory and real life.

You could start by asking: *How can we see the blocks?* Some may recall that light is reflected from the blocks. Continue by asking why the blocks appear to be different colours. *How does this work?* The light shining on the blocks is the same. It is unlikely that many learners will reach the correct answer, but this does not matter at the start of the lesson. The questions serve to start learners thinking about how this works and helps you to pick up on misconceptions or gaps in prior learning. Any seemingly strange answers should be sensitively followed up, as these may indicate errors in understanding.

Your management of a starter activity can completely change a learner's perception of that activity. As a challenge, consider making this change to the start of a lesson, Instead of getting the learners seated, explaining what the lesson involves, then calling learners to the front for a demonstration, as learners arrive tell them only to place their belongings at their desks, not to sit down but to come straight to the front for the demonstration.

After trying some different starters, ask yourself:

- What has been the most successful starter activity you have done so far?
- What aspect of the lesson did this starter improve?
- What was it about this starter that made it successful?
- Can you transfer these successful parts of this starter to make other activities equally, or more, successful?





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# Topic 6.1: Reflection

## LEARNING OBJECTIVES

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| **8Ps.01** Describe reflection at a plane surface and use the law of reflection. (LB, WB, WS)<br><br>**8TWSm.01** Describe what an analogy is and how it can be used as a model (WB)<br><br>**8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. (LB)<br><br>**8TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately. (LB)<br><br>**8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. (LB)<br><br>**8TWSc.07** Collect and record sufficient observations and/or measurements in an appropriate form. (LB)<br><br>**8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results. (LB)<br><br>**8TWSa.03** Make conclusions by interpreting results and explain the limitations of the conclusions. (LB) | • Describe how light is reflected from a plane surface.<br><br>• Understand the law of reflection.<br><br>• Draw ray diagrams to show reflection of light. | • Use the law of reflection to state angles of incidence or reflection when provided with one of these angles.<br><br>• Draw labelled ray diagrams, correctly applying the law of reflection at a plane mirror. |





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## LANGUAGE SUPPORT

Learners will use the following words:

**reflection:** term given to the bouncing back of, in this topic, light from a surface, without being absorbed

**plane mirror:** a flat silvered surface usually covered with glass that is designed to reflect light

**rays:** straight lines that represent the movement of light

**incident:** arriving at something

**incident ray:** the ray coming onto a surface

**perpendicular:** at right angles to

**normal:** perpendicular to something

**protractor:** equipment used to measure angles on diagrams

**set square:** piece of equipment in the shape of a right-angled triangle used in drawing diagrams

**angle of incidence:** the angle between the incident ray and the normal

**angle of reflection:** the angle between the reflected ray and the normal

**ray diagram:** the use of labelled lines to show what happens to light when incident on a surface

**law of reflection:** statement of the fact that the angle of incidence and angle of reflection are equal

## Common misconceptions

| Misconception | How to elicit | How to overcome |
|---|---|---|
| Reflected light is only associated with glare. | Ask learners to give examples of where light is reflected. | The Think like a scientist activity in the Learner's Book should help overcome this. |

## Starter ideas

### 1 Getting started (5 minutes)

**Description:** Learners should recall that light travels in straight lines. Giving evidence of this is a little more challenging. The formation of shadows that are the same shape as the object is an example.

### 2 Sentence completion (5 minutes)

**Resources:** Prepared slide or sentences written on a board

**Description:** Learners complete sentences about the way light travels, for example:

- Light travels in … lines
- We see things because light … from them.
- We can use a … diagram to show how light travels.

## Main teaching ideas

### 1 Activity: Mirrors and reflections (10 minutes)

**Learning intention:** To recall how and why mirrors are used and also to recall other objects that cause reflections.

**Description:** Learners recall some of the uses of mirrors. In the second part of the activity, when asked for other objects that cause reflections, learners will probably recall shiny objects such as glass or polished metal. However, the activity is designed to differentiate by outcome, and learners should have previously learned that all objects that do not give out their own light can only be seen because of reflection.

› **Differentiation ideas:** For a question that differentiates by outcome, ask learners what other objects, besides mirrors, reflect light. Learners that need more support will probably suggest shiny





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objects in which they can see their reflection, or those that cause glare. Learners that need more challenge should realise that all objects cause reflection and that is the reason why we can see these objects. Only those that are shiny will enable a clear reflected image to be produced.

› **Assessment ideas:** Learners could swap answers with other pairs and discuss any similarities or differences in their work.

## 2 Think like a scientist: Measuring angles of incidence and reflection (30 minutes, to include graph plotting)

**Learning intention:** To construct accurate ray diagrams using a ray box and a plane mirror, and to investigate how the angles of reflection and incidence are related.

**Resources:** See the Learner's Book.

**Description:** See the Learner's Book.

**Safety:** some ray boxes become hot after prolonged use; the ray box should only be switched on to take measurements; learners should not touch the ray box until after it has been switched off and allowed to cool.

› **Practical guidance:** The investigation works best if the room can be darkened, or at least direct sunlight be excluded.

› **Differentiation ideas:** Learners that need more support could be given guidance on how to measure the angles from the normal, as many learners may attempt to measure the angles from the mirror surface.

Some combinations of ray boxes and plane mirrors produce two reflected rays: one, faintly, from the outer surface of the glass and the other, more strongly, from the silver surface behind the glass. If effects such as this are observed, then learners that need more challenge could be asked to explain this.

› **Assessment ideas:** Ask learners about patterns in their results or ask them to make predictions while they are doing the investigation. They can also be asked about difficulty in making accurate measurements (a pencil blocks the light ray; the light ray may be quite wide).

## 3 Laser reflections – direct sunlight can also be used (10+ minutes)

**Learning intention:** To show reflection from plane mirrors.

**What idea is good for:** Whole-class activity; teacher demonstration; making observations

**Resources:** Laser pointer; small unmounted plane mirrors; adhesive tape or sticky gum; clamp stand; darkened room

**Description:** Fix a small plane mirror to the wall above the eye level of seated learners. Direct the light from the laser pointer to the mirror to produce a reflection on another wall. Clamp the laser in this position and mark the position of the reflected beam on the wall. Fix another mirror to the wall in this position, so the beam will be reflected again.

Direct sunlight can also be used for a similar activity.

**Safety:** Learners should not look directly into the laser beam or into the reflected beam from sunlight; the beams should be directed at a high level so not to pass, even by accident, into learners' eyes.

› **Differentiation ideas:** At each stage, ask learners to predict, roughly, where the reflected beam will appear. Remind learners that need more support about using the law of reflection.

Reflected light beams are used in some security systems. Learners that need more challenge could be asked to suggest how these systems work. (The reflected beam or beams are directed onto a light sensor. When the beam is broken, the light sensor is no longer activated, and an alarm is switched on.)

› **Assessment ideas:** The questions asked during the activity form part of the assessment, as learners make predictions and explanations based on the law of reflection.

# Plenary ideas

## 1 Taboo words (3–5 minutes)

**Description:** Learners work in pairs. They take turns at explaining reflection without using one or more taboo words. These taboo words can be keywords such as 'mirror', 'reflection', 'angle of incidence'.





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**Assessment ideas:** Listen to some of the groups' explanations. Ask learners that were not heard to volunteer to share their explanations with the class.

## 2 What my partner learned today (5 minutes)

**Resources:** Paper; pens; timing provided by the teacher

**Description:** Learners work in pairs. Each has 20 seconds to tell their partner what they learned in the lesson. After this time, each learner makes a list of the things that their partner said.

**Assessment ideas:** Learners can do this activity in their notebooks for assessment with the next homework, or as exit slips.

## Homework ideas

1. Learner's Book questions.
2. Workbook exercises 6.1A–6.1C.
3. Worksheet 6.1

## Topic worksheets

Worksheet 6.1 Reflection in a plane mirror

# Topic 6.2: Refraction

## LEARNING OBJECTIVES

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| 8Ps.02 Describe refraction of light at the boundary between air and glass or air and water in terms of change of speed. (LB, WB, WS) | • Describe how light is refracted at the boundary between air and glass or air and water. | • Predict which direction (toward or away from the normal) light will bend when passing between air and either glass or water, or going the opposite way. |
| 8TWSp.04 Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. (LB) | • Describe how light changes speed when it passes between different substances. | • State whether light will speed up or slow down when crossing a boundary. |
| 8TWSc.03 Evaluate whether measurements and observations have been repeated sufficiently to be reliable. (LB) | • Draw ray diagrams to show how light is refracted. | • Construct ray diagrams for refraction at air-glass and air-water boundaries and the opposite way. |





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CONTINUED

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| **8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. (LB)<br>**8TWSc.07** Collect and record sufficient observations and/or measurements in an appropriate form (LB)<br>**8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results. (LB)<br>**8TSWa.05** Present and interpret observations and measurements appropriately. (LB) | | |

LANGUAGE SUPPORT

Learners will use the following words:

**distorted:** changed in some way from the original

**Refraction:** term given to light changing direction on crossing a boundary due to a change in speed of the light

**medium:** in this topic, the transparent material through which light is passing

**bent:** changed direction; in refraction at boundaries this is a sudden change and not a curve

**towards the normal:** the angle between the light ray and the normal becomes smaller

**away from the normal:** the angle between the light ray and the normal becomes larger

**angle of incidence:** the angle between the light ray arriving at a surface and the normal

**angle of refraction:** the angle between the light ray that has been refracted and the normal

**lenses**: specially shaped pieces of transparent material designed to refract light in particular directions

## Common misconceptions

| Misconception | How to elicit | How to overcome |
|---|---|---|
| Light passes through a transparent material without changing direction. | After learning about refraction, ask whether light changes direction when coming through the window. | Present objects such as windows as thin glass blocks and relate this to the Think like a scientist activity. |




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## Starter ideas

### 1 Getting started (5 minutes)

**Description:** This activity allows learners to think about how light passes through transparent materials. Learners should include materials such as air (gas), water (liquid) and glass (solid) for transparent materials. When they are thinking about why images are distorted through a glass of water, prompt learners to think about how light travels from the object through the glass and the water.

### 2 Looking through transparent objects (5 minutes)

**Resources:** Access to a clear glass window; water

**Description:** Ask learners whether glass or water, or both, is transparent. Ask what 'transparent' means. If there is rain or condensation on the window, task: Why can't we see clearly through the window, if both water and glass are transparent? If there is no water on the window, dip your fingers in water, then flick the water at the window to cause drops of water to fall on the window.

Learners are not necessarily expected to reach the correct explanation, as they have not yet learned about refraction, but they should begin thinking about what happens to light as it passes through these materials.

Take care not to introduce the misconception that refraction is random and unpredictable. Refraction is predictable, but the presence of many curved surfaces on the water drops causes the appearance of disorder.

## Main teaching ideas

### 1 Activity: Refraction effects (10+ minutes)

**Learning intention:** To show the effect of light changing direction when passing through boundaries.

**Resources:** See the Learner's Book.

**Description:** See the Learner's Book.

› **Differentiation ideas:** Ask learners that need more support where other effects such as this may be seen.

After they have learned about refraction, ask learners that need more challenge to draw a ray diagram for a light ray passing through an object of circular cross-section (ignoring the possibility of total internal reflection), using the same principles as for a flat surface.

› **Assessment ideas:** Ask learners whether light is travelling straight through the materials or bending. What evidence can they give for their answer?

### 2 Think like a scientist: Drawing accurate ray diagrams (20–30 minutes, including graph plotting)

**Learning intention:** To use ray boxes and glass blocks to construct accurate ray diagrams for light being refracted.

**Resources:** See the Learner's Book.

**Description:** See the Learner's Book.

› **Differentiation ideas:** Learners may notice partial reflection of the incident light ray at one or both surfaces. Ask learners that need more support for the term that describes this (reflection). Ask learners who need more challenge whether this partial reflection obeys the law of reflection. This could also be an opportunity to overcome the misconception that light can only be absorbed, reflected or refracted and not any two or more of these.

› **Assessment ideas:** Ask learners to compare angles of incidence and refraction at both surfaces. Ask: *Is the light ray bending towards or away from the normal in each case?*

### 3 Reversing with water (10–15 minutes)

**Learning intention:** To show refraction effects.

**Resources:** Paper; marker pens; drinking glass with circular cross-section or glass beaker; water

**Description:** Learners draw an image, such as an arrow, on the paper and prop this up on the table. They place the glass or beaker in front of the drawing so they are viewing the drawing through the glass. The drawing should appear distorted. Learners pour water into the glass until they are viewing the drawing through the water. If viewed in the correct way, the drawing will appear reversed.

**Answers**: Light travels from the drawing, through the water, to the eyes. On refraction, the light rays from the left and right of the drawing cross over, making the drawing appear reversed.





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› **Differentiation ideas:** Ask learners who need more support to name the effect where light changes direction when passing from air into glass or water.

Ask learners who need more challenge to try to explain the observation using a ray diagram. Ask whether a second glass of water could be used to reverse the drawing again, back to its original orientation.

› **Assessment ideas:** Ask what phenomenon is causing the effect (refraction) and ask why light is refracted when passing from air into water or glass (the light slows down). Ask how many boundaries the light crosses (four: air into glass, glass into water, water into glass, glass into air).

## Plenary ideas

### 1 More examples of refraction (3–5 minutes)

**Description:** Ask learners to give any other examples of where refraction may occur. These should be different from the examples already used in a class activity, but could be variations on them.

› **Assessment ideas:** Ask learners questions about their named example. If a learner says 'glasses' then ask, for example: *What is light passing from, and what is it passing to, when it is refracted? Where or how does light change speed?*

### 2 Useful or not? (3–5 minutes)

**Resources:** Paper; pens

**Description:** Learners work in pairs. They divide their paper into two columns, headed 'useful' and 'not useful'. They write examples of refraction in each column; for example, refraction in contact lenses is useful, rain on a window is not useful.

› **Assessment ideas:** The work can be handed in as exit slips.

## Homework ideas

1 Learner's Book questions.

2 Workbook exercises 6.2A–6.2C.

3 Worksheet 6.2.

## Topic worksheets

Worksheet 6.2 Refraction in water and glass

# Topic 6.3: Making rainbows

**LEARNING OBJECTIVES**

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| 8Ps.03 Know that white light is made of many colours and that this can be shown through the dispersion of white light, using a prism (LB, WB, WS)<br>8TWSm.01 Describe what an analogy is and how it can be used as a model. (LB)<br>8TWSm.02 Use an existing analogy for a purpose. (LB) | • Learn how white light is made from many colours.<br>• Discover how dispersion of white light can be done with a prism.<br>• Recall the colours of white light in the correct order. | • Recall that white light is actually a combination of 7 colours of light.<br>• Draw a diagram to show how a ray box and a prism can be used to show dispersion of light.<br>• List the seven colours in the order that they occur in the spectrum of white light, starting from red. |






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CONTINUED

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| **8TWSc.01** Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys. (LB)<br>**8TWSc.05** Carry out practical work safely, supported by risk assessments where appropriate. (LB)<br>**8TWSc.07** Collect and record sufficient observations and/or measurements in an appropriate form (LB)<br>**8TWSa.02** Describe trends and patterns in results, including identifying any anomalous results. (LB)<br>**8TWSa.04** Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes. (LB) | | |



## LANGUAGE SUPPORT

Learners will use the following words:

**spectrum**: in this topic, a continuous range of colours, each colour merging with the next

**dispersion**: the splitting of white light into its component colours

**triangular**: in the shape of a triangle

**prism**: in this topic, a block of transparent material with a regular shape



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## Common misconceptions

| Misconception | How to elicit | How to overcome |
|---|---|---|
| Sunlight and light from an electric lamp is colourless/sunlight is yellow. | After learning about dispersion, ask (separately) what colour, or colours of light come from an electric lamp and from the Sun. | This will be more easily overcome in the next topic on colours of light, but in this topic the dispersion experiment can be done to show the component colours of light from a lamp. This is slightly more difficult to do with sunlight, but use of a slit to create a beam of sunlight to shine through the prism will work. |

## Starter ideas

### 1 Getting started (5 minutes)

**Description:** This activity starts learners thinking about the component colours in white light. If learners have never seen a rainbow, show them pictures. Learners should identify that both sunlight and water droplets are required. Some may realise that rainbows are seen when the Sun is behind the observer. Learners may recall some of the seven colours, although possibly not in order.

**Note:** Some learners may have mythological beliefs about rainbows. These should be respected, but point out that the scientific aspect of colours will be covered in this topic.

### 2 Draw part of a rainbow (5–10 minutes)

**Resources:** Paper; colouring pens pencils or crayons representing each of the seven colours of the rainbow, if possible

**Description:** Give learners a picture of a rainbow. Without being told how many colours there are, learners draw a cross-section of the rainbow. The idea is that learners see there are different colours, but that the colours merge together. Set a time limit on the activity, as some learners will take a very long time, which is not required.

## Main teaching ideas

### 1 Think like a scientist: Making a rainbow (20–30 minutes, to include both parts)

**Learning intention:** To show how a prism can be used to disperse white light on a screen and to observe the colours of light directly.

**What idea is good for:** Making observations; drawing diagrams; viewing a spectrum

**Resources:** See the Learner's Book.

**Description:** See the Learner's Book.

› **Differentiation ideas:** Question 6 from *Think like a scientist: Making a rainbow* will differentiate by outcome, and some learners can be given support with questions such as: *How is the image on the screen similar to a rainbow; how is it different from a rainbow?*

Learners who need a challenge could be asked if they can understand why Newton may have originally only observed five or six colours.

› **Assessment ideas:** Ask learners to recall the seven colours in order, starting from red.

### 2 Reproducing Newton's experiment (15–20 minutes)

**Learning intention:** To show dispersion of sunlight in a similar manner to Newton's first demonstration.

**What idea is good for:** Making observations; drawing diagrams; viewing a spectrum

**Resources:** Triangular prism; clamp stand; large board with a small hole; direct sunlight (or desktop lamp); white screen

**Description:** Similar to the Think like a scientist activity with two main differences:

1 **Safety:** Learners must **not** look directly into the dispersion pattern.





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**2** The Sun (or a desk lamp) is used as the light source in place of a ray box; the large board forming the slit.

The purpose of the large board, besides forming the slit, is to cast a shadow on the screen so that the spectrum can be seen more clearly. The darker the room can be, the better. The clamp stand is used to support the prism, so that it does not need to be held by hand.

› **Differentiation ideas:** Ask learners who need more support to give similarities and differences between the dispersion pattern and a rainbow.

Ask learners who need more challenge about how this present day demonstration may differ from Newton's original demonstration. *What is the significance of us being able to repeat the demonstration 400 years later?*

› **Assessment ideas:** Use class discussion to assess answers.

### 3 Dispersion in water (15–20 minutes)

**Learning intention:** To dmonstrating that dispersion of white light will also occur with water.

**What idea is good for:** Making observations; drawing diagrams; viewing a spectrum

**Resources:** Ray box; rectangular glass tank such as a fish tank; water; white screen; books or blocks

**Description:** Set the ray box on books or blocks and position the tank so the ray of light passes through the corner of the tank, effectively making the corner of the tank act as a triangular prism. Demonstrate on the white screen that dispersion does not occur in the same way as it did with the prism.

Fill the tank with water to a depth where the ray will pass through the water (and the glass sides). Demonstrate that dispersion is observed through water.

› **Differentiation ideas:** Ask learners who need more support to name the parts of the apparatus that represent **a** the raindrops **b** the Sun in this model of rainbow formation.

Ask learners who need more challenge: What is the purpose of showing that dispersion does not occur with the empty tank? (To show it is not the glass sides that is causing the dispersion.)

› **Assessment ideas:** Ask learners what other materials, besides glass and water might cause dispersion. (Any transparent object – diamonds could be used as an example, although total internal reflection should **not** be introduced.)

## Plenary ideas

### 1 Three skills (3–5 minutes)

**Resources:** Small pieces of paper printed with three questions, for example: *Write down one previously learned skill you used in this lesson; Write down one new skill that you learned in this lesson; Write down one skill that you would like to learn.*

**Description:** Each learner writes their name and answers the three questions, handing them in before they leave. Learners are given this opportunity to reflect on their own ability in experimental work, and the skills that they used.

› **Assessment ideas:** From reading the statements, it should be clear what skills have been learned or are required.

### 2 Summarise the lesson (2–3 minutes)

**Resources:** Paper; pens

**Description:** Ask learners to summarise the lesson in a given number of bullet points. For example, they could be asked to summarise the lesson in four bullet points.

› **Assessment ideas:** Learners could compare each other's bullet points, or volunteer to share their own for class discussion.

## Homework ideas

1 Learner's Book questions.

2 Workbook exercises 6.3A–6.3C.






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# Topic 6.4: Colours of light

## LEARNING OBJECTIVES

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| **8Ps.04** Describe how colours of light can be added, subtracted, absorbed and reflected. (LB, WB, WS)<br><br>**8TWSp.03** Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding. (LB)<br><br>**8TWSp.04** Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests. (LB)<br><br>**8TWSp.05** Make risk assessments for practical work to identify and control risks. (LB)<br><br>**8TWSc.02** Decide what equipment is required to carry out an investigation or experiment and use it appropriately. (LB)<br><br>**8TWSc.03** Evaluate whether measurements and observations have been repeated sufficiently to be reliable. (LB)<br><br>**8TWSc.04** Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. (LB)<br><br>**8TWSc.05** Carry out practical work safely, supported by risk assessments where appropriate. (LB)<br><br>**8TWSc.07** Collect and record sufficient observations and/or measurements in an appropriate form. (LB) | • Discover what happens when colours of light are added.<br><br>• Discover what happens when colours of light are subtracted.<br><br>• Discover why we see different colours. | • Recall the results of the addition of two or more primary colours of light.<br><br>• Describe the effects of coloured filters on white light and on the primary colours of light.<br><br>• Predict how white, black and primary coloured objects will appear in white light and light of each of the primary colours |





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CONTINUED

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| 8TWSa.02 Describe trends and patterns in results, including identifying any anomalous results. (LB)<br>8TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions. (LB)<br>8TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes. (LB)<br>8TSWa.05 Present and interpret observations and measurements appropriately. (LB) | | |

LANGUAGE SUPPORT

Learners will use the following words:

**primary colours**: the name given to red, green and blue light as they cannot be made from the addition of any other colours of light

**magenta**: the colour of light that results from the addition of red and blue light

**cyan**: the colour of light that results from the addition of blue and green light

**coloured filters**: transparent but coloured pieces of glass or plastic that absorb all other colours of light

**transmit**: to allow light through

**absorbed**: the term given to light that is neither reflected nor transmitted

**subtraction**: taking away

## Common misconceptions

| Misconception | How to elicit | How to overcome |
|---|---|---|
| Colour is a property of objects and not a property of light. | After teaching about why objects appear to be certain colours due to reflection, ask where colour comes from. | Show learners how objects appear in different colours of light, but be careful to restrict this to primary colours only. For example, show a red object in **a** white light **b** red light **c** green or blue light. If colour was a property of the object, then the red object would appear red in any colour of light. |

*(continued)*



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| Misconception | How to elicit | How to overcome |
| --- | --- | --- |
| | | You can also show a white object in **a** white light **b** red light **c** green light **d** blue light. Again, if colour was the property of the object, then it would appear white in all colours of light. |
| A coloured filter adds that colour to light as it passes through. | After teaching about filters, ask what, for example, a green filter would do to white light. Ask whether it does this by adding green to the light or subtracting the other colours. | Show the effect of two filters together, but take care that these are of primary colours only. For example, show white light passing through a blue filter, then onto a green filter. No light is emitted from the second filter because of subtraction. If filters added colour, then it would not be possible to end up with no light. |



## Starter ideas

### 1 Getting started (5 minutes)

**Description:** Ask learners should list the colours. Do not restrict these to the seven colours of the spectrum learned in Topic 6.3. Learners can introduce shades, such as light green, dark green. Other colours can be used, such as pink, purple, orangey-red.

**Note:** Not everyone sees the exact same colours.

### 2 Is it red? (2–3 minutes)

**Learning intention:** To show the effects of different colours of light on objects.

**Resources:** Light source; red (or any colour) filter; two small pieces of paper the same size: one red (or the same colour as the filter), the other white

**Description:** Fix the two pieces of paper in front of the filtered light before learners arrive. Call them, as a group, to the front and ask whether one, both or neither of the pieces of paper is red (or the other colour that is used).

Turn off the filtered light and demonstrate that one is red and the other white. Turn the light back on again to show the repeatability of the effect.

**Note:** When learners see an effect that surprises them, or that they cannot immediately explain, they may attribute this to 'magic'. Do not tell them that this is wrong, but emphasise that, with understanding, they will be able to explain what they have seen.

## Main teaching ideas

### 1 Activity: Making colours on the screen (15+ minutes)

**Learning intention:** To show how the primary colours of light can be added, in varying quantities, to make all the other visible colours.

**Resources:** See the Learner's Book.

**Description:** See the Learner's Book.

› **Differentiation ideas:** Ask learners who need more support what colour would be produced if **a** all the primary colours are set to maximum **b** all the primary colours are set to zero.

Ask learners who need more challenge how other shades of colour could be made, such as lighter or darker magenta (lighter: have red and blue at maximum, and add green; darker: have red and blue lower than maximum and no green).

› **Assessment ideas:** Ask learners why the three colours that can be adjusted are red, green and blue. Why are yellow, orange, etc. not included? (These are the primary colours, and all other colours can be made from addition of these.)

### 2 Think like a scientist: Identify the colour (10–20 minutes, depending on the number of colours used)

**Learning intention:** To observe the effects of different colours of light on coloured writing.

**Resources:** See the Learner's Book.



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**Description:** See the Learner's Book.

› **Differentiation ideas:** Give learners who need more support a summary of whether a primary coloured object will appear the correct colour or black, depending on the colour of light used to illuminate it. This could be provided in a table. Alternatively, they could produce the table themselves, with guidance.

Ask learners who need more challenge: *What would happen if light of another colour, other than a primary colour, was used? For example, magenta light contains both red and blue light. What colour would a blue object appear in magenta light?*

› **Assessment ideas:** Ask learners to make predictions and explain them, on the basis of reflection.

### 3 Explaining addition of colour in light (5–10 minutes)

**Learning intention:** To understand addition of colour with light.

**Resources:** Learner's Book image showing adding colours

**Description:** Learners will be familiar with mixing paints and that brown is the result of mixing red, green and blue. This can cause confusion when they are learning about adding colours of light. Explain that mixing more pigments results in the mixture becoming darker, whereas mixing more light results in the mixture becoming lighter. Hence, adding all the primary colours of light results in white – the lightest possible.

› **Differentiation ideas:** Encourage learners who need more support to develop their own mnemonic to help recall the colours produced when the different primary colours are added.

Ask learners who need more challenge what the result would be of adding all three primary colours of light, but having one slightly brighter. For example, if red is slightly brighter than the other two, then a very pale red will result.

› **Assessment ideas:** Ask learners to predict the outcome of mixing each pair of coloured lights, or all three primary colours of light.

## Plenary ideas

### 1 Five top tips (3–5 minutes)

**Resources:** Paper and pen or pencil

**Description:** Learners work in pairs to write five 'top tips' of advice to help others who are learning in this topic.

› **Assessment ideas:** Learners can write the tips with their next homework, or hand them in as exit slips. Alternatively, learners can volunteer to share their tips with the class for discussion.

### 2 Ask the class (5 minutes)

**Resources:** Paper and pens

**Description:** Learners pretend they are the teacher. Ask: *What questions would you choose to ask the class after teaching this topic?* Learners can then ask some of their questions. Learners reflect on their own understanding of the topic by considering what questions would be important to ask.

› **Assessment ideas:** Assessment can be carried out based on both the questions and the answers.

## Homework ideas

1. Learner's Book questions.
2. Workbook exercises 6.4A–6.4C.
3. Worksheets 6.4A–6.4C.

## Topic worksheets

Worksheets 6.4A–6.4C Coloured filters





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# Topic 6.5: Galaxies

## LEARNING OBJECTIVES

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| 8ESs.01 Describe a galaxy in terms of stellar dust and gas, stars and solar systems. (LB, WB)<br>8TWSm.01 Describe what an analogy is and how it can be used as a model. (LB)<br>8TWSm.02 Use an existing analogy for a purpose. (LB)<br>8TWSm.03 Use symbols and formulae to represent scientific ideas. (LB)<br>8TWSc.02 Decide what equipment is required to carry out an investigation or experiment and use it appropriately. (LB)<br>8TWSc.03 Evaluate whether measurements and observations have been repeated sufficiently to be reliable. (LB)<br>8TWSc.04 Take appropriately accurate and precise measurements, explaining why accuracy and precision are important. (LB)<br>8TWSc.07 Collect and record sufficient observations and/or measurements in an appropriate form. (LB)<br>8TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes. (LB) | • Discover that galaxies contain dust, gas, stars and other solar systems. | • State what a galaxy contains. |




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## LANGUAGE SUPPORT

Learners will use the following words:

**galaxy:** a collection of dust, gas, stars and solar systems held together by gravity

**spiral:** a type of galaxy shape with curved arms extending from the centre

**universe:** all of space

**elliptical:** a type of galaxy shape that is oval

**irregular:** a type of galaxy shape that is not well defined and not regular

## Common misconceptions

| Misconception | How to elicit | How to overcome |
|---|---|---|
| The Sun is not part of a galaxy | After teaching about galaxies, ask whether the Sun is part of any galaxy. | Explain that the majority of stars exist in galaxies apart from some, known as 'rogue stars' or 'stellar outcasts' that are believed to have once been in galaxies but somehow became separated. |

## Starter ideas

### 1 Getting started (2–3 minutes)

**Description:** Learners consider the relative sizes of objects in space. Learners should know at least some of the relative sizes of these objects, and be able to arrange some of the list correctly.

**Note:** The activity is to compare the actual sizes of the objects, not their apparent size when viewed from Earth.

### 2 Where do we live? (5 minutes)

**Resources:** Internet access

**Description:** Use an internet search engine to find images showing where we are in the Milky Way. Images will show the position of the Earth in one of the outer arms of the spiral galaxy. Explain that most of the stars we see in the night sky are part of this galaxy.

## Main teaching ideas

### 1 Think like a scientist: Estimating large numbers (20+ minutes)

**Learning intention:** To show how the number of a set of objects that are too numerous to count can be estimated.

**Resources:** See the Learner's Book. Fine sand is not ideal, as the grains are too small.

**Description:** See the Learner's Book.

**Differentiation ideas:** Give learners who need more support examples of large numbers that are estimates, such as global human population. Ask them to give reasons why these numbers cannot be known accurately.

Ask learners that need more challenge to suggest other numbers that are estimates and why an estimate is sufficient, in these cases, rather than the exact number. Question 8 from *Think like a scientist: Estimating large numbers* will differentiate by outcome.

**Assessment ideas:** Learners can answer questions 1–7 from *Think like a scientist: Estimating large numbers* and question 8 of the activity can be used as an extension.

### 2 What do galaxies look like? (10–30 minutes, depending on structure of activity)

**Learning intention:** To view images of galaxies.

**Resources:** Internet access for learners, in groups of two to three





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**Description:** There are many websites with high quality images of other galaxies outside the Milky Way. Some are actual photographs taken via telescopes such as the Hubble Space Telescope, while others are artists' impressions. Allow learners to perform their own searches or guide them to specific websites, such as hubblesite.org.

Set learners a task, such as producing a document or slideshow with information about galaxies. They should write the text in their own words and not merely copy from websites.

› **Differentiation ideas:** Ask learners who need more support questions about why we need telescopes to see galaxies that resemble these images. (They are very far away.)

Remind learners who need more challenge about the topic in Stage 7 giving formation about the Solar System and ask them to suggest how galaxies may have formed. (Theory suggests that galaxies also formed from large clouds of dust and gas pulled together by gravity.)

› **Assessment ideas:** Ask learners questions about what galaxies contain.

### 3 Galaxies in the universe (10–20 minutes)

**Learning intention:** To show how our understanding of our galaxy and the rest of the universe has changed in recent times.

**Resources:** Access to an internet video resource (optional)

**Description:** Until 1924, the stars in the Milky Way galaxy were thought to comprise all the stars that existed in the universe. Edwin Hubble's calculations of the distances of some stars showed them to be much further away than could be possible if they were in our galaxy. It was not until 1995 that hundreds more galaxies were being discovered.

There are videos on the internet telling the same story. Learners could be asked to complete the story themselves, in any form or presentation, but in their own words.

› **Differentiation ideas:** The activity will differentiate by outcome. Learners will, at the very least, discover that our understanding of space and other galaxies has changed dramatically in the last 100 years. Other learners may extend this to find out how galaxies are discovered, together with the implications of these discoveries for estimates of the age and size of the universe.

› **Assessment ideas:** Ask learners questions, based on Science in Context learning objectives, such as how our understanding in science progresses with time.

## Plenary ideas

### 1 Make a puzzle (3–5 minutes)

**Resources:** Paper and pen or pencil

**Description:** Learners work in pairs. Each learner writes a set of anagrams of the key words associated with this topic. They swap with their partner and attempt to solve. Each other's anagrams.

› **Assessment ideas:** The activity can be extended by the learners writing a short clue for each of their anagrams.

### 2 Story board summary (10 minutes)

**Resources:** Paper; pencils

**Description:** Learners summarise the content of the lesson in the form of a story board.

› **Assessment ideas:** There should be sufficient time in the activity for you to check content or ask questions of individuals.

## Homework ideas

1 Learner's Book questions.

2 Workbook exercises 6.5A–6.5C.


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# Topic 6.6: Rocks in space

## LEARNING OBJECTIVES

| Curriculum reference | Learning intentions | Success criteria |
|---|---|---|
| 8ESs.02 Describe asteroids as rocks, smaller than planets, and describe their formation from rocks left over from the formation of the solar system. (LB, WB)<br>8TWSp.01 Identify whether a given hypothesis is testable. (LB)<br>8TWSp.02 Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry. (LB)<br>8TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions. (LB) | • Discover that asteroids are rocks that are smaller than planets.<br>• Know that scientists believe asteroids to be rocks left over from the formation of the Solar System. | • Describe what asteroids are.<br>• Explain the possible origin of asteroids. |



## LANGUAGE SUPPORT

Learners will use the following words:

**asteroids**: rocky objects that are smaller than planets, found mostly between the orbits of Mars and Jupiter

**asteroid belt**: a region in the Solar System with many asteroids, forming an almost circular ring around the Sun between the orbits of Mars and Jupiter and in the same plane as these orbits

**craters**: hollowed out area that can be caused by the impact of another object

**impacts**: word given to the collisions of smaller objects with larger ones

## Starter ideas

### 1 Getting started (5 minutes)

**Description:** Learners should be able to recall the Sun and planets, and also know that some planets, besides Earth, have moons. Learners can include artificial objects such as satellites and space probes. Some learners may already have heard of asteroids.

### 2 Looking at asteroids (2–3 minutes)

**Resources:** Internet access

**Description:** Show images of asteroids. Give learners information about the approximate sizes of these objects.

## Main teaching ideas

### 1 Activity: Making a model asteroid (20–30 minutes)

**Learning intention:** To model an asteroid.

**Resources:** See the Learner's Book.



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**Description:** See the Learner's Book.

› **Differentiation ideas:** The activity will differentiate by outcome, based on the way in which learners construct their models. Some learners may need support with answering the calculation questions, while learners who need challenge can do these without support.

› **Assessment ideas:** Questions in the Learner Book could be answered individually on paper, or used for class discussion.

### 2 Think like a scientist: What happened at Tunguska? (10–30 minutes, depending on the structure of the activity)

**Learning intention:** To show how evidence can be used to support or contradict a hypothesis.

**Resources:** Internet access (optional)

**Description:** See the Learner's Book. If internet access is available, other interesting and relevant facts about the Tunguska event can be researched, including statements from people who saw or heard the event.

› **Differentiation ideas:** The questions will differentiate by outcomes.

› **Assessment ideas:** The questions can be answered individually or in small groups, then the answers can be used as the basis for class discussion.

### 3 The asteroid belt (5–10 minutes)

**Learning intention:** To describe the asteroid belt.

**Description:** A common misconception arising from science fiction and computer games is that the asteroid belt is densely packed with asteroids, so that a space probe travelling through the belt would have a higher chance of impacting an asteroid than not.

It should be explained that the total mass of asteroids in the asteroid belt is estimated to be 4% of the mass of the Moon and that the average distance between any two asteroids in the belt is almost 1 000 000 km.

› **Differentiation ideas:** Remind learners who need more support of the equation time $= \frac{\text{distance}}{\text{speed}}$ and ask them to calculate the time taken to travel 1 000 000 km in a car travelling at a constant sped of 50 km/h with no breaks. If necessary, help them to convert their answers from hours to days. This will help them comprehend how far apart asteroids are.

Learners who need more challenge could perform this calculation on their own and extend to working out the time taken to fly in an aeroplane doing a constant 900 km/h without breaks. They could convert their answers into days.

› **Assessment ideas:** Learners could be given the radius of the asteroid belt (480 000 000 km) and asked to work out the length of the belt.

## Plenary ideas

### 1 Complete the sentence (5–10 minutes)

**Resources:** Paper; pens

**Description:** Learners work in pairs. Each writes some sentences to be completed by the other in the pair. They swap sentences, complete each other's and then discuss them.

› **Assessment ideas:** Take the opportunity to check some of the sentences, to ensure the information is correct.

### 2 Write a mnemonic (5–10 minutes)

**Resources:** Paper; pens

**Description:** Learners write a mnemonic that would help them remember a new word or fact that they learned today.

› **Assessment ideas:** Mnemonics can be shared with the class.

## Homework ideas

1 Learner's Book questions.

2 Workbook exercises 6.6A–6.6C.






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# Unit guidance

## PROJECT GUIDANCE

### Investigating refraction

When a sugar or salt solution is poured into pure water, the solution can be seen as being different to the water, although both are transparent. This is because the solution refracts light differently to the water, so light passing though the mixture bends where the solution meets the water.

The aim is for learners to investigate how dissolving solutes in water affects the refraction of light.

For example, dissolving sugar in water increases the refraction. Learners can relate this to the change in speed of the light. Teachers should not introduce the term refractive index, as this is not required at this stage.

Learners should present results in a logical way and attempt to use their results to answer the original question.





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