# Light on the move

**Name** ______________________________ **Class** ____________ **Date** _____________

**1** Write S (for sound) or L (for light) next to each of these statements.

**a** can travel through empty space ____

**b** travels at 330 m/s in air ____

**c** transverse wave ____

**d** travels at 300 000 000 m/s in air ____

**e** can travel through all solid objects ____

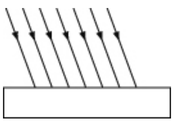
**f** longitudinal wave ____

**2** Draw lines to match the words to their meanings.

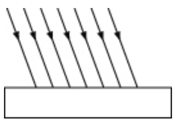
| | |
|---|---|
| absorbed | a material that lets light pass through without scattering |
| transparent | a material that scatters the light passing through it |
| transmitted | when light bounces off a material |
| translucent | when light passes through a material |
| reflected | a material that light cannot pass through |
| opaque | when light is taken into a material |

**3** Complete these diagrams to show what happens when light hits different materials.

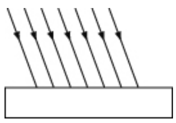
**a** opaque



**b** transparent



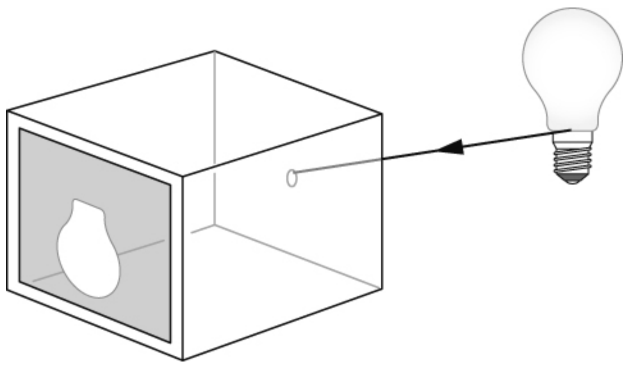
**c** translucent



**4 a** Label the pinhole camera using words from the box.

| image | pinhole | screen |
|---|---|---|

**b** Draw lines to show how the image is formed. One line has been started for you.



**I can…**

- compare light and sound waves
- describe what can happen to light when it hits different surfaces
- describe how a pinhole camera works.

Your teacher may watch to see if you can:
- make careful measurements.

## Aim

To compare the amount of light reflected by different materials.

## Introduction

You can use light sensors to measure the amount of light reflected by different materials.

## Method

### Apparatus

- datalogging equipment
- light sensor
- 2 clamps and stands
- selection of materials
- light source (ray box or torch)

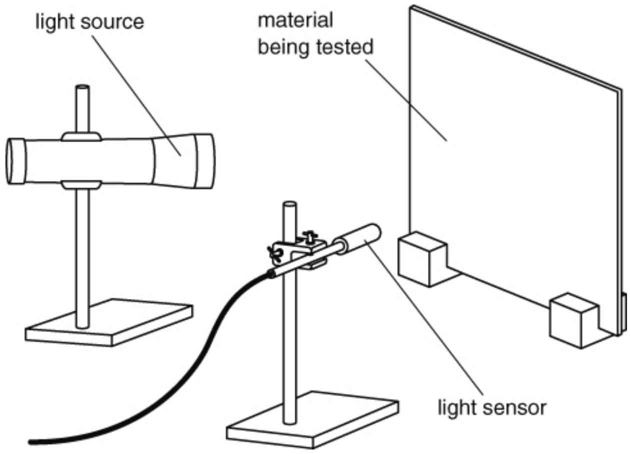
⚠ Take care if moving about in a darkened room.
Do not look directly at the bulb or touch it while it is hot.

**A** The room will need to be dark for the measurements to be reasonably accurate.

**B** Set up the apparatus as shown in the diagram using one of the materials to be tested.

**C** Place the light sensor so that it gives the highest possible reading with the light source switched off. Record this reading and keep the light sensor in this place for the rest of the investigation.

**D** Switch on the light source and record the reading on the light sensor. The difference between this reading and the one you took in step C is the amount of light being reflected by the material.




**E** Repeat steps C and D with your other materials.

## Recording your results

**1** Draw a table like the one below for your results.

| Material | Reading with light off | Reading with light on | Amount of light reflected |
|---|---|---|---|
| | | | |

**2** Draw a bar chart to show your results. Show the materials in the order of the amount of light they reflected. Start with the one that reflected least light.

## Considering your results/conclusions

**3** Could you have predicted the order of your results just by looking at the materials? Explain how.

## Evaluation

**4** **a** How fair do you think your comparisons were? Were there any factors you could not keep the same each time?

**b** How could you improve the accuracy of your results?

**I can…**
- carry out an investigation safely
- draw conclusions
- evaluate an investigation and suggest improvements.

## Aim

To investigate how the size and number of holes in a pinhole camera affects the image.

## Hypothesis

**1** Images in a pinhole camera can be bright or dim, and can be sharp or blurred. Write down a hypothesis to suggest what the type of image depends on.

## Prediction

**2** Look at the diagrams below. Use your hypothesis to help you to predict the kind of image you will see in each case, choosing words from the box. Explain your predictions.

## Method

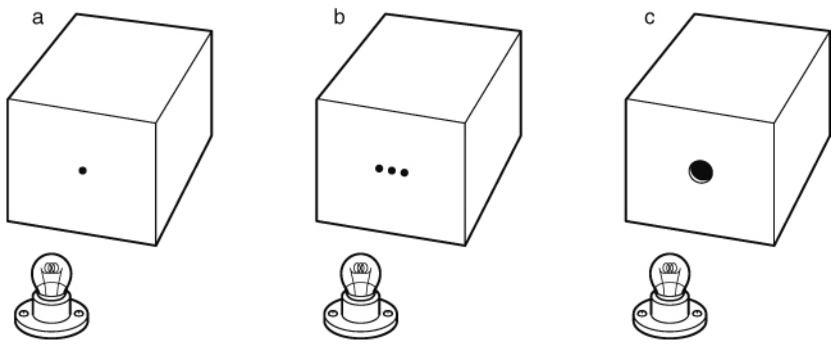
**Apparatus**

- pinhole camera
- bright light source
- dim light source

⚠ Do not look at the Sun. It will damage your eyes.

Do not look directly at the bulb or touch it while it is hot.

**A** Investigate the image formed in each camera using the dim light and then the bright light.




| |
|---|
| blurred |
| large |
| multiple |
| sharp |
| single |
| small |
| upright |
| upside down |

## Recording your results

**3** For each investigation, write down:

- **a** what you were changing (your independent variable)
- **b** what you were keeping the same (your control variables)
- **c** what you predicted would happen
- **d** what actually happened and whether your prediction was correct.

## Considering your results/conclusions

**4** What is the difference between the images formed by a dim and a bright light? Explain why this difference occurs.

**5** What effect did changing the hole size have on the image? Draw a diagram to help you to explain this effect.

**6** What happened when you changed the number of holes? Draw a diagram to help you to explain what happened.

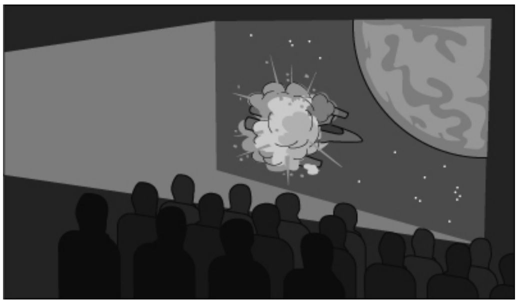
**I can…**

- make predictions about what I will find in an investigation
- use diagrams to explain how images are formed in pinhole cameras.

**Name** ______________________ **Class** __________ **Date** ___________

Allie and Jamil are watching a film in the cinema. A spaceship is being chased, and explodes in a ball of fire. Allie puts her fingers in her ears because the sound is so loud.

Jamil drops his sweets. He needs to use the torch on his phone to find them because it is very dark under the seats.



**1** Which of these things are light sources. Tick (✓) *two* boxes.

☐ torch ☐ cinema screen ☐ projector

**2** If you were really in space, you could see an explosion but you could not hear it. Why is this?

☐ light travels faster than sound

☐ sound travels faster than light

☐ sound cannot travel through empty space

**3** Complete these sentences using words from the box. You do not need to use all the words.

| absorbs | transmits | reflects | opaque | shadow | transparent |
|---|---|---|---|---|---|

**a** The cinema screen is made from a material that ____________________ light well.

**b** It is dark under the seats because they are ____________________ (light cannot go through them) so they form a ____________________.

**4** Draw arrows on the diagram to show how Jamil can see his sweets using the torch on his phone.

**5** Outside the cinema they see two cars crashing in the distance. They don't hear the sound straight away. Why does this happen?

________________________________________

________________________________________

**I can…**

- describe the ways in which light can be affected by different materials
- explain why sounds cannot be heard in space
- compare light waves and sound waves
- use ray diagrams to explain how we see things.

The speed of light is 300 000 km/s. It takes light from the Sun 8.5 minutes to reach Earth. It takes 1.3 seconds for light to travel from the Moon to Earth. The nearest star to the Earth (other than the Sun) is called Proxima Centauri. It takes light 4 years to reach us from Proxima Centauri.

> You may need to use these formulae to answer some of the questions. Use units of km/s for speed, km for distance and s for time.
>
> speed = distance ÷ time    time = distance ÷ speed    distance = speed × time

**1** **a** Copy the diagram and draw rays to show how people on the Earth can see the Sun.


**b** Draw rays to show how people on the Earth can see the Moon.

**2** If we could travel as fast as light, how long would it take to reach Proxima Centauri?

**3** **a** Jupiter is a planet that is approximately five times further away from the Sun than we are. How long will it take for light from the Sun to travel to Jupiter?

**b** Mars is half as far again from the Sun as the Earth. How long will it take for light to travel from the Sun to Mars? Give your answer to the nearest minute.

**4** Approximately how long will it take for light to travel from the Sun to the Moon? Explain your answer. (*Hint*: look at the diagram in question 1 – you don't need to do any calculations to get your answer.)

**5** Calculate the distances below. You will need to convert the times to seconds before working out your answers.

**a** Sun to Earth

**b** Earth to Moon

**c** Earth to Proxima Centauri

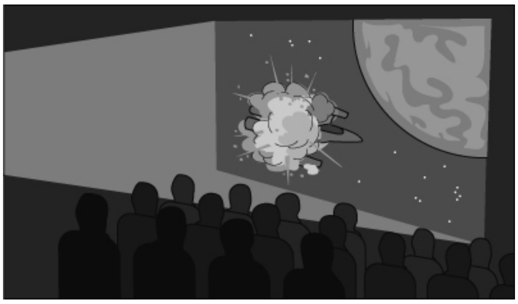
**6** Mercury is the closest planet to the Sun. On average it is at a distance of 58 000 000 km from the Sun. Calculate how long it takes for light to get from the Sun to Mercury.

**I can…**

- explain how we can see the Moon
- calculate distances and times.

# At the cinema 2

Allie and Jamil are watching a film in the cinema. A spaceship is being chased, and explodes in a ball of fire. Allie puts her fingers in her ears because the sound is so loud.



Jamil drops his sweets. He needs to use the torch on his phone to find them because it is very dark under the seats.

Someone walks down the aisle and sits in the empty seat next to Jamil.

**1** **a** If you were really in space, you could see an explosion but you could not hear it. Why is this?

**b** You watch an explosion on Earth. Do you see the flames or hear the bang first? Explain your answer.

**c** Give *two* other differences between sound waves and light waves.

**2** The cinema screen is made out of a special material. Explain which of these properties it should have: good at absorbing light, good at transmitting light, good at reflecting light.

**3** Sketch a diagram to show how Allie can see the images of a spaceship. Your diagram should include the source of light.

**4** The person that sits next to Jamil finds their seat without needing a torch. Explain how they can see to find the seat. Include a sketch with light rays on as part of your answer.

**5** Explain why Jamil needs to use his torch to find his sweets.

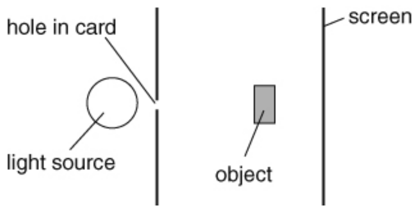
**6** The light travels from the projector to the screen in straight lines. Explain why people in the cinema can often see where the beam of light goes.

**I can…**

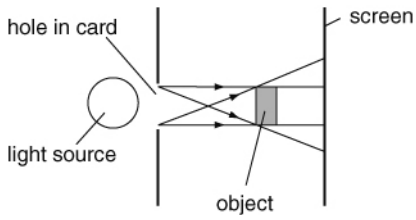
- describe the ways in which light can be affected by different materials
- explain why sounds cannot be heard in space
- compare light waves and sound waves
- use ray diagrams to explain how we see things.

The diagrams show light from a bulb shining through a hole in a piece of card. The light shines on an object, which casts a shadow on a screen.

A




B




**1** Copy diagram A and mark rays on it to show where a shadow will form on the screen. Add labels to explain why a shadow is formed there.

**2** Explain, using diagrams, how the size of the shadow will change if:

**a** the object is moved closer to the light source.

**b** the screen is moved further away from the light source.

**3** Copy diagram B and mark on it:

**a** an area where no light from the bulb can reach the screen

**b** two areas where light from all of the hole in the card can reach the screen

**c** two areas where only some of the light passing through the hole can reach the screen.

**4** When light from a small source (such as the small hole in the card in diagram A) is blocked, the shadow has sharp edges. When light from a large source is blocked, the shadow has fuzzy edges. Use your answers above to help you to explain this difference.

**I can…**

- use a ray diagram to explain how shadows are formed
- use a ray diagram to explain the effect of various factors on shadow size.

**Name** ______________________________ **Class** ____________ **Date** _____________

**1** Fill in the gaps in these sentences using words from the box.

| incidence | reflect | reflection | scatter |
|---|---|---|---|

Mirrors ____________ light evenly, so that the angle of _____________ (*r*) is equal to the angle of ____________ (*i*).

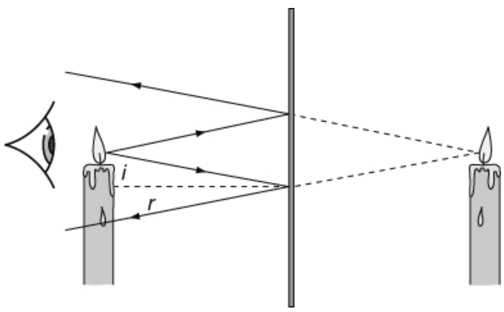
Most opaque materials ____________ the light when they reflect it, so that it goes off in all directions.

**2** Tick (✓) the boxes to show how each material will reflect light.

| | Specular (even) reflection | Diffuse (scattered) reflection |
|---|---|---|
| **a** paper | ☐ | ☐ |
| **b** polished metal | ☐ | ☐ |
| **c** brick | ☐ | ☐ |
| **d** wood | ☐ | ☐ |

**3** **a** Label the diagram using words from the box.

| angle of incidence | angle of reflection | image | incident ray |
|---|---|---|---|
| | mirror | reflected ray | |




**b** Look at the diagram above. How big is the image of the candle? Tick (✓) *one* box.

☐ smaller than the real candle ☐ the same size ☐ bigger than the real candle

**I can…**

- describe how different surfaces reflect light.

### Aim

To find out how the angle of reflection depends on the angle of incidence.

### Apparatus

- ray box
- plane mirror and stand
- scissors

⚠ Do not look directly at the bulb or touch it while it is hot.

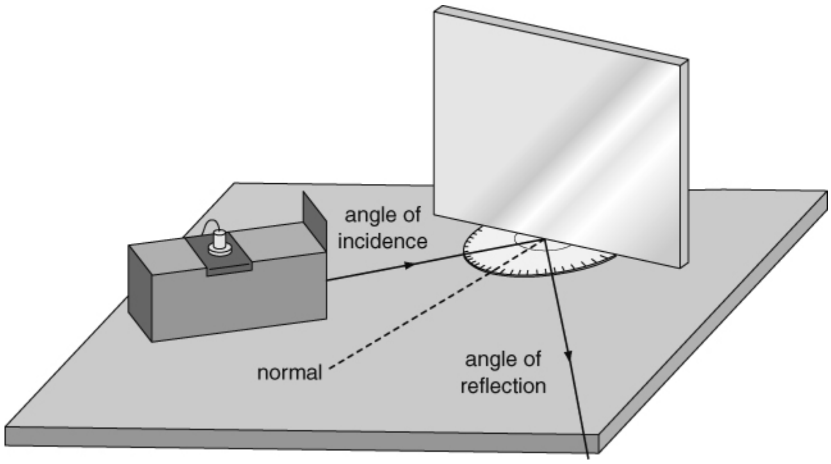
### Method

**A** Cut out the protractor from the bottom of this sheet, then set up the apparatus as shown in the diagram.

**B** Switch on the ray box and shine the ray of light at the point marked X. Make sure it shines along one of the lines marking the angles.

**C** Write down the angle of incidence and the angle of reflection.

**D** Repeat steps B and C for other angles.




### Recording your results

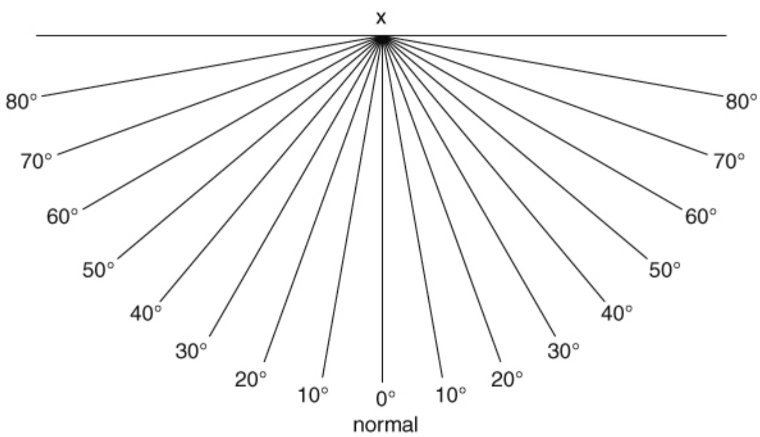
**1** Record your results in a table.

### Considering your results/conclusions

**2** What do you notice about the angle of reflection compared to the angle of incidence?

**I can…**

- measure angles
- draw a conclusion from my results.



# Make a periscope

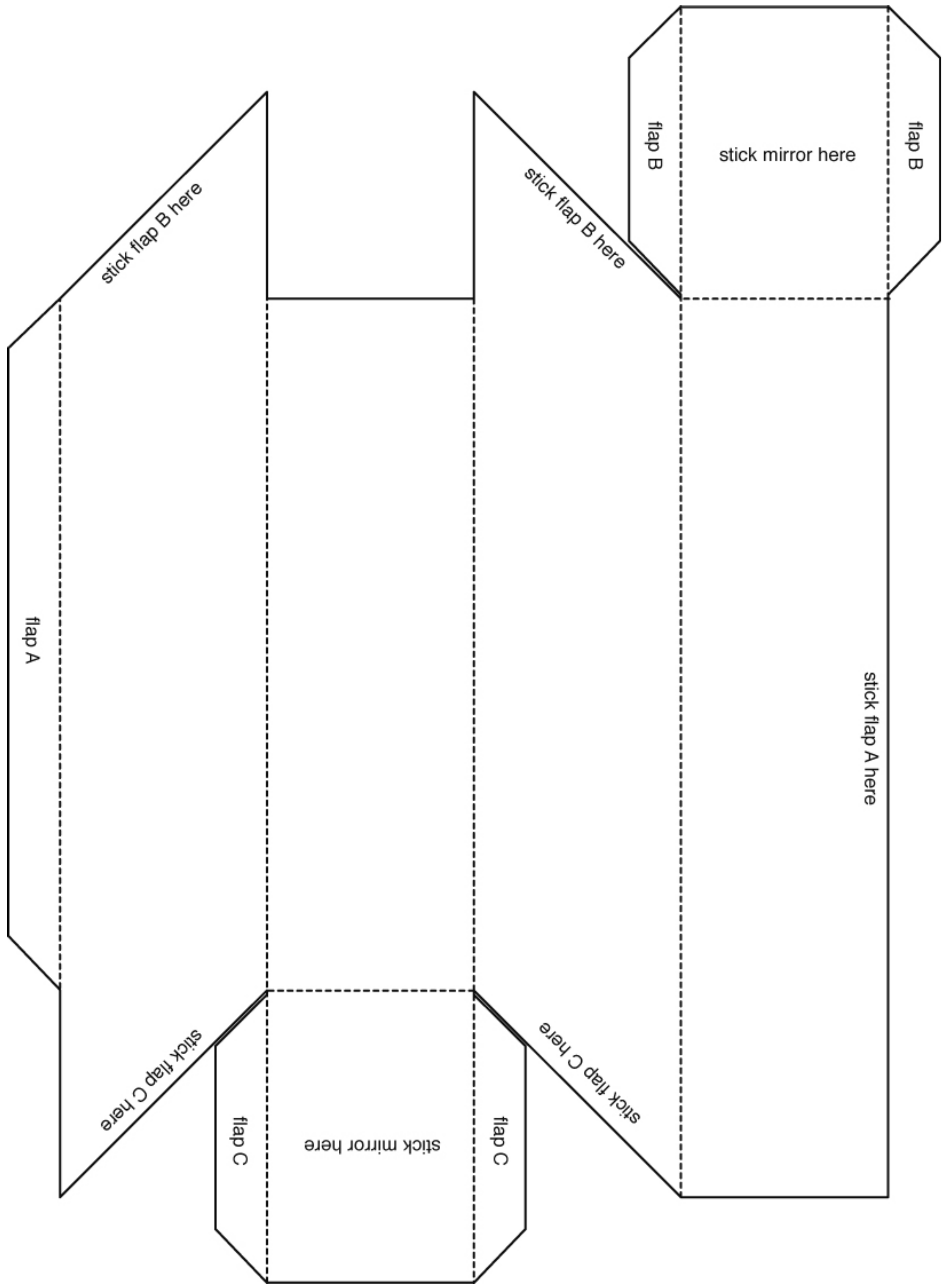
1 Stick this worksheet onto a piece of card.

2 Cut out the shape of the periscope, and fold it along the dotted lines.

3 Follow the instructions on the drawing to make it into a periscope.

**I can...**

- follow instructions to make a periscope.



## Aim

To investigate the different kinds of image you can see in curved mirrors, and to explain the ways in which curved mirrors reflect light.

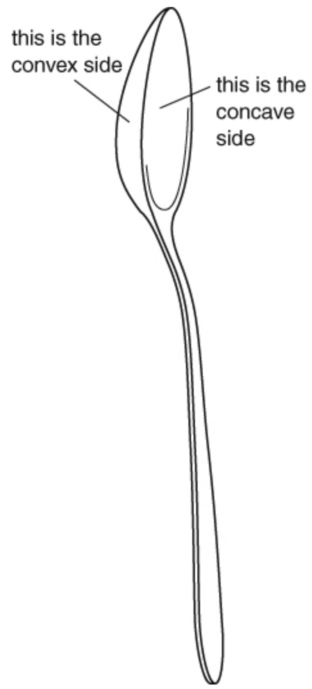
## Introduction

Curved mirrors can be described as concave or convex, depending on which way they curve. The two sides of a spoon act as concave and convex mirrors, so you can use a spoon to investigate the kinds of images you see in both types of mirror.

## Method

**Apparatus**

- concave mirror
- convex mirror
- ray box and power pack
- triple slits
- plain paper




### Describing images

**A** Look at your image in a convex mirror (or the convex side of a spoon). Describe it carefully. Does it seem bigger or smaller than your face? Is it the right way up? Does it change if you move the mirror closer or further away?

**B** Now look at your image in a concave mirror or the concave side of a spoon, and describe it carefully.

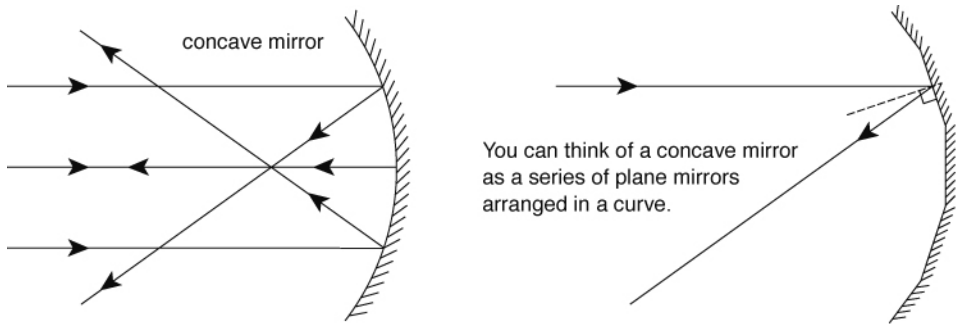
### Method: How the mirrors reflect light

**C** Set up the ray box so that it shines three rays of light at a convex mirror. Record what happens to the rays.

**D** Repeat step C for a concave mirror.

### Considering your results

You can use a model to help you to explain why curved mirrors reflect light as they do.




**1** Copy the model of the concave mirror and add rays to it to explain how a real concave mirror reflects light rays.

**2** Make a similar drawing of a convex mirror and a model of the mirror. Add rays to show how the convex mirror reflects light, and how the model helps to explain this.

**I can...**

- make careful observations
- record results in a clear way
- use a model to explain how curved mirrors reflect light.

# Ray diagrams for mirrors

Copy the ray diagrams below onto plain paper, and complete them.

- You will find this easier if you make the diagrams larger than they are here. But make sure you leave enough space around the diagram to complete it.
- Follow the method below to help you to complete your diagrams.

**Method**

**Apparatus**

- protractor
- pencil
- ruler

**A** Draw a ray of light from the object to the mirror. Put an arrow on it to show which way the light is travelling.

**B** Draw a normal at right angles to the mirror where your light ray hits the mirror. Use your protractor to make sure the angle is exactly 90°.

**C** Carefully measure the angle of incidence.

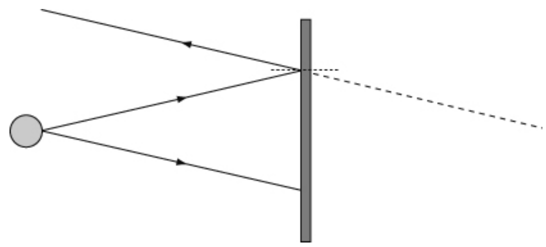
**D** Draw the reflected ray so that the angle of reflection is the same as the angle of incidence. Use your protractor to make sure the angle is drawn accurately.

**E** Repeat steps A to D for the other diagrams.

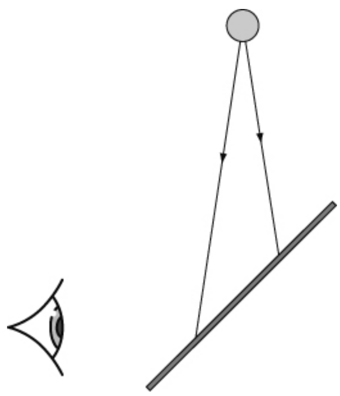
**F** Extend your two reflected rays behind the mirror until they meet. The point where they meet is where the image will be.

**G** Check how accurate your drawing is by measuring the distances between the object and the mirror and between the mirror and the image. If you have drawn it accurately, the two distances should be the same.

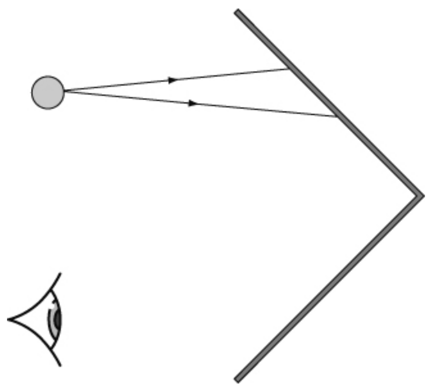
**1**



**2**



**3**



**I can…**

- draw accurate ray diagrams
- use a ray diagram to work out the position of the image in a mirror.

# Mirrors and reflections 1

**Name** ______________________ **Class** __________ **Date** __________

**1** Light is reflected by a mirror. How big is the angle of reflection compared to the angle of incidence? Tick (✓) *one* box.

☐ bigger

☐ the same size

☐ smaller

**2** What is the angle between the normal and the mirror? Tick (✓) *one* box.

☐ 45°

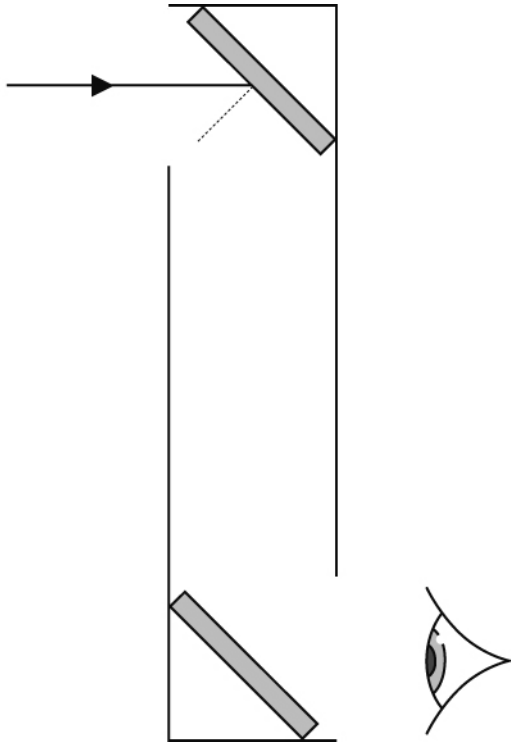
☐ 60°

☐ 90°

**3** Periscopes can be used to see over things. The diagram shows a ray of light entering a periscope.

**a** Complete the lines to show the path of light to the eye.

**b** Add arrowheads on the lines to show the direction the rays are travelling.



**4** Label the following things on the diagram:

**a** label the normal with an *n*

**b** label the angle of incidence at the top mirror with an *i*

**c** label the angle of reflection at the top mirror with an *r*

**d** label the incident ray at the bottom mirror with *ir*

**e** label the reflected ray at the bottom mirror with *rr*

**5** How is the light reflected by a mirror different to the light reflected by a piece of paper?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

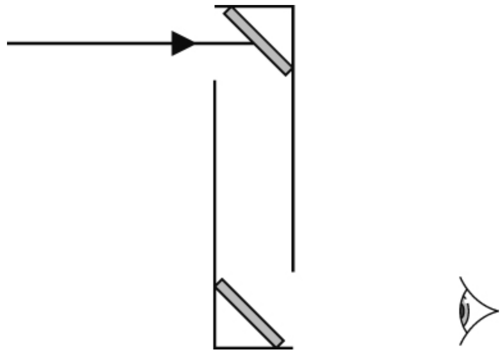
**I can…**

- recall key words connected with mirrors
- describe how different surfaces reflect light.

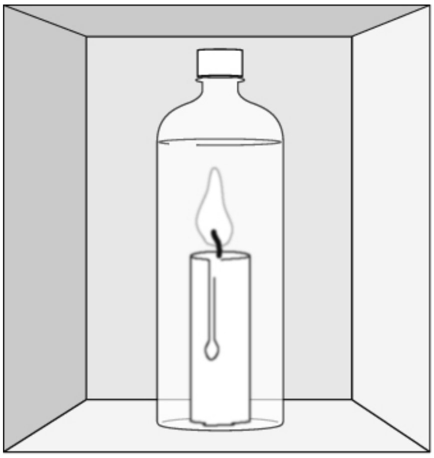
**1** **a** Copy the diagram on the right and complete the lines to show the path of light to the eye.

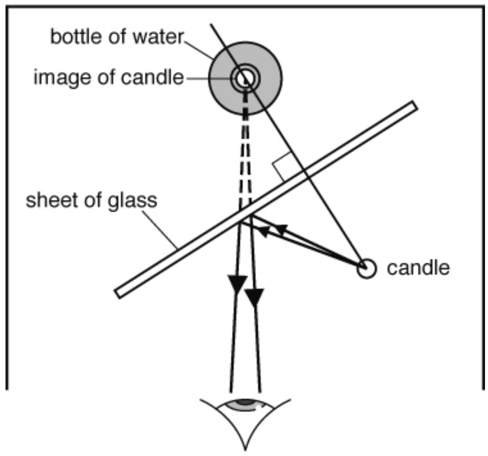
**b** Add arrowheads on the lines to show the direction the rays are travelling.

**c** Explain why two mirrors are needed in the periscope.



**2** You can use a sheet of glass to make it look as if a candle is burning inside a bottle of water.






The candle is not really inside the water. The diagram shows how this illusion is created.

**a** Describe the path of the rays of light that let the person see the bottle of water.

**b** Describe the path of the rays of light that let the person see the candle.

**c** Why is a sheet of glass used rather than a mirror?

**d** Suggest why the bottle and sheet of glass need to be in a box.

**3** A similar method was used in theatres in the nineteenth century to make a ghost appear and disappear on stage. This type of illusion was first created by Henry Dircks in 1862. John Pepper adapted Dircks' method to make it simpler to create the effect in theatres, and the effect has been called 'Pepper's Ghost' ever since. The actor playing the 'ghost' stands in a darkened part of the stage hidden from the audience, and a spotlight lights up the actor when the ghost has to appear. A reflection of the actor appears on a diagonal piece of glass across the part of the stage that the audience sees.

**a** Why does the actor playing the ghost have to stand in a darkened part of the room?

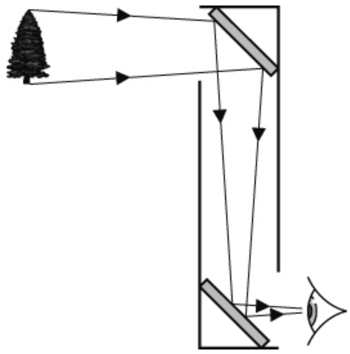
**b** Why does using a spotlight make the ghost 'appear' on stage?

**c** What practical problems do you think have to be overcome to make this illusion work successfully?

**I can…**

- explain some effects of reflection using the idea of light rays.

The diagram shows the path of two rays of light from a tree. The tree is being viewed through a periscope.



**1** Explain why the image of the tree that the person sees is upright (the right way up).

**2** The diagram is a model to help us to think about what is happening when we look through a periscope. The diagram shows only two rays of light coming from the tree.

Explain why only two rays are drawn.

**3** You look at two trees of the same height (without a periscope). One is twice as far away from you as the other.

Draw a ray diagram to show why the more distant tree looks smaller. (*Hint*: the size an object appears to be depends on the angle at which rays of light meet at your eye.)

The image in a mirror is the same distance behind the mirror as the object is in front.

**4** Sketch a copy of the periscope diagram.

**a** Mark on your diagram where the image of the tree would be if you looked directly into the top mirror.

**b** The image you see in the bottom mirror is a reflection of the image in the top mirror. Mark on your diagram where this image is.

**5** Use the diagram you drew for question 4 to help you to explain these statements:

**a** The image of the tree you see through the periscope is further away than the tree itself.

**b** If you make a periscope with a longer tube, the image you see through it will be smaller.

Periscopes can be used at sporting events to help people to see over the heads of other spectators. They are also used in tanks and submarines.

**6** Suggest why periscopes are useful in tanks and in submarines.

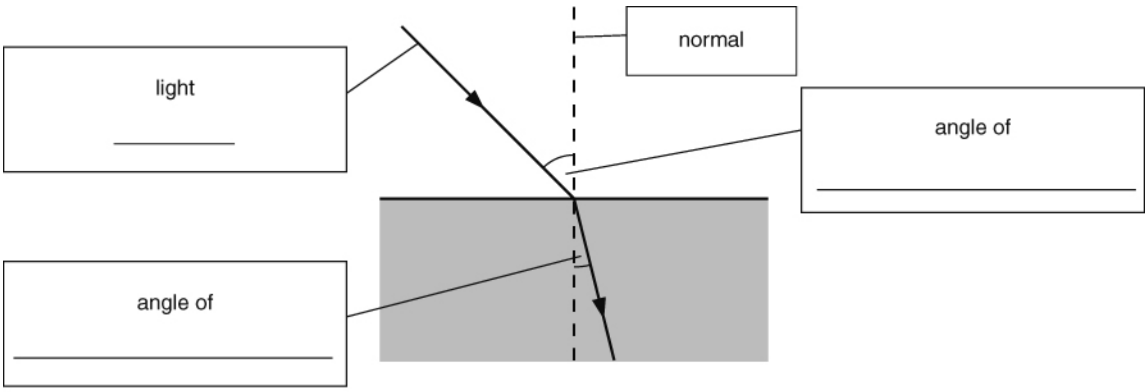
**7** Suggest why the periscopes in submarines need to include lenses to help to magnify the image.

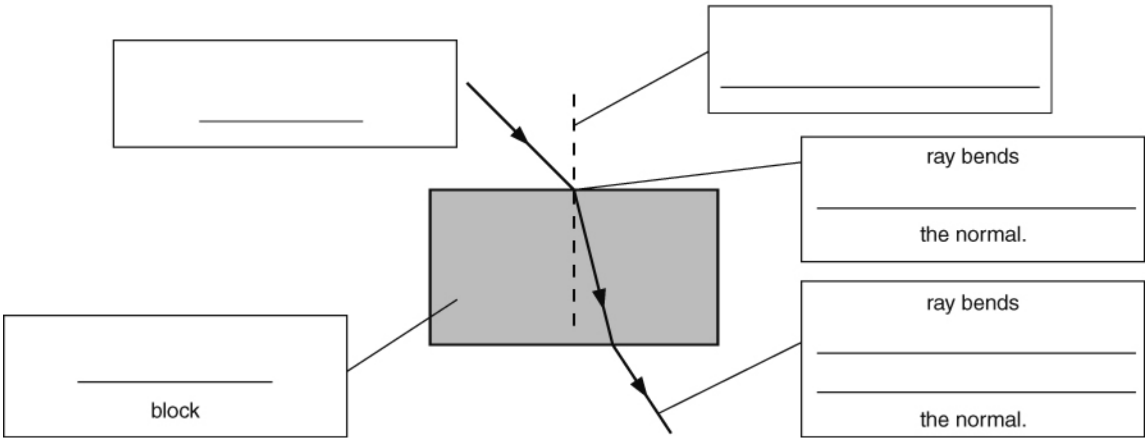
**I can…**

- use ray diagrams to explain some of the features of images in periscopes.

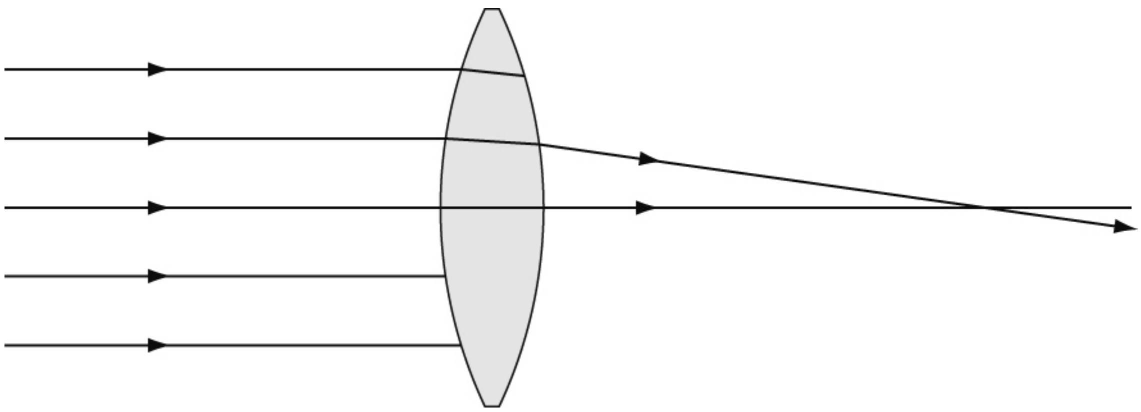
**Name** ______________________ **Class** __________ **Date** __________

**1** Label the diagrams.




**2** Finish drawing the rays going through this lens.



**3** What 'R' is the name for light changing direction? ______________________

**I can…**

- describe how light changes direction when it goes from one material into another.

Name ______________________ Class __________ Date __________

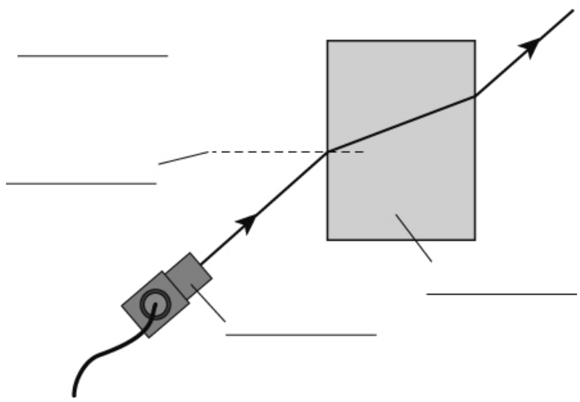
Your teacher may watch to see if you can:
- make accurate measurements of angles.

**Aim**

To investigate what happens when a ray of light travels through a glass block.

**Apparatus**
- ray box
- rectangular glass
- plastic block
- pencil
- ruler
- sheet of plain paper

⚠ Do not look directly at the bulb or touch it while it is hot.



1 Label the diagram using words from the box.

| | | | |
|---|---|---|---|
| air | glass | normal | ray box |

**Method**

2 Fill in the gaps in these sentences, using words from the box below.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| angle | block | draw | glass | light | move | ray | ruler |

I will find out what happens when a ray of light travels from air into ____________.

I will do this by shining a ray of ____________ into the glass block. Before I start I will ____________ around the glass block so that I can put it back in the same place if I ____________ it. I will mark the path of the ____________ of light where it goes into the glass block. I will mark the path of the ray where it comes out of the glass ____________. I will use a ____________ to join the rays to show where the ray of light went inside the glass block. I will repeat the experiment by changing the ____________ that the light hits the glass.

**Considering your results/conclusions**

3 Look at the lines you have drawn on your paper, then complete these sentences.

I noticed that the ray of light is refracted ____________ (away from/towards) the normal when it goes into a glass block. The ray of light is refracted ____________ (away from/towards) the normal when it comes out of a glass block. The ray coming out of the glass block is ____________ (parallel/at right angles) to the ray going into the block.

**I can...**
- make careful observations
- draw conclusions from my observations.

## Aim

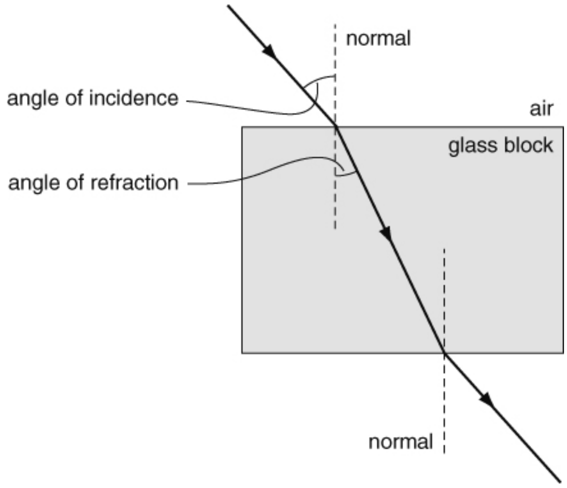
To investigate what happens when a ray of light travels through a glass block.

## Introduction

The direction of a ray of light changes when it moves from one transparent material to another.

## Planning

Plan an investigation into the way that a block of glass (or other transparent material) affects the path of light travelling through it. These questions will help you to plan your investigation.




**1** What question are you going to investigate? Some possible questions are:

- how does the angle of refraction change when you change the angle of incidence?
- does the amount of refraction depend on which solid material light travels through?
- how does the angle of the ray leaving the block change if you change the angle of the ray entering the block?
- how does the position at which the light ray leaves the block change if you change the angle of incidence?

**2** What are the variables in this investigation? Which one(s) will be:

- the independent variable
- the dependent variable
- the control variable(s)?

**3** How will you carry out your investigation? Write a method that describes:

- what apparatus you need
- what you will do
- how you will make sure your measurements are as accurate as possible
- what precautions you will take to stay safe
- how you will record and present your results.

**4** Ask your teacher to check your plans before you start.

## Considering your results/conclusion

**5** What conclusion can you draw from your results?

## Evaluation

**6** Do you have enough information to support your conclusion?

**7** Explain how you could improve your method if you had time to do the investigation again.

**I can…**

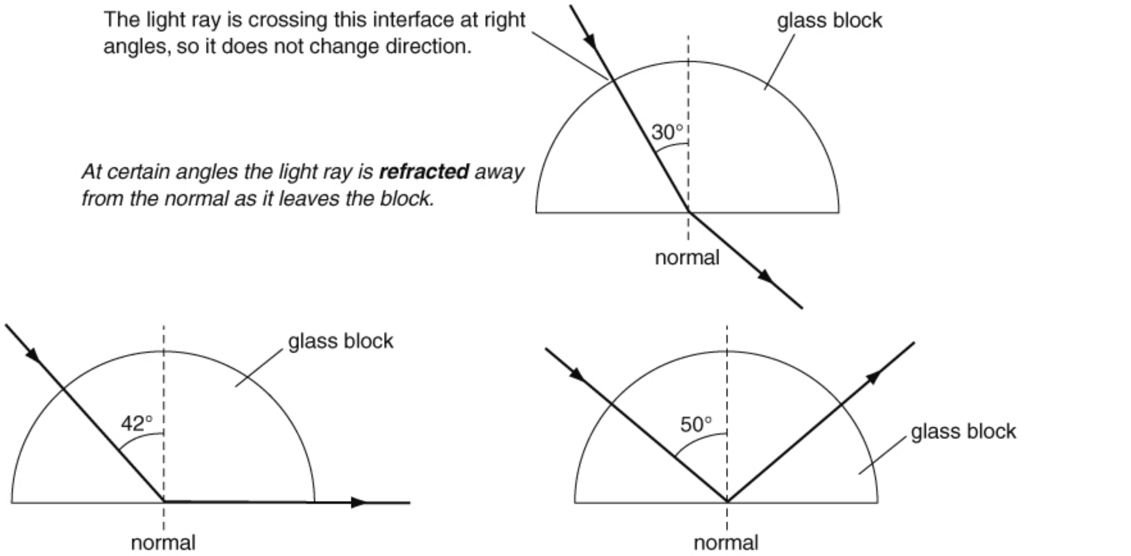
- plan a safe and fair investigation
- control risks to myself and others.

## Aim

To find the critical angle for light leaving a glass or perspex block.

These diagrams show what happens when a ray of light is shone through a semi-circular transparent block.




*The angle at which the ray of light is refracted so much that if goes along the edge of the block is called the **critical angle**. The critical angle is different for each combintion of two different materials*

*At larger angles the ray is **reflected** back through the block. This is called **total internal reflection**.*

## A Finding the critical angle

How would you find the critical angle for light going from glass or Perspex into air?

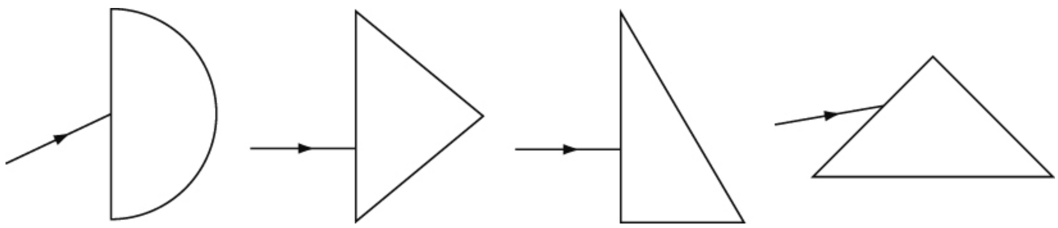
**1** What apparatus will you need?

**2** Write a method for your investigation before you start.

**3** Show your plan to your teacher, and then carry out your investigation.

## B Investigating total internal reflection

Investigate what happens when you send a ray of light through the glass blocks from different directions. Make sure you include the directions shown below.



**4** Predict what will happen to the rays before you start.

**5** Draw diagrams to show what you have found out about the different-shaped blocks.

**6** Do all your blocks show total internal reflection in all directions? If not, why not?

**I can...**

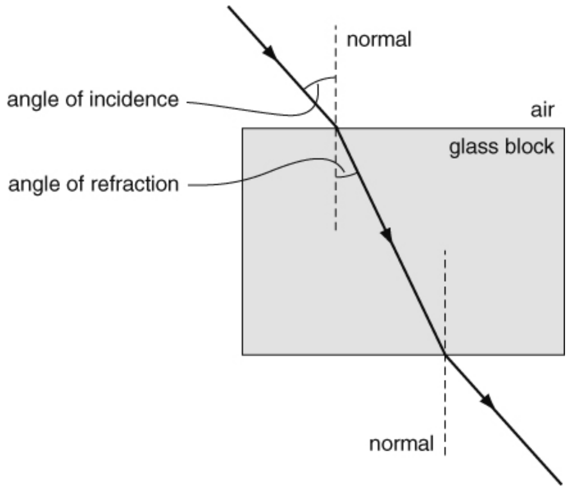
- plan and carry out an investigation
- draw a conclusion.

# Refraction questions

**Name** ______________________ **Class** __________ **Date** __________

**1** The normal is a line at right angles to the edge of a glass block. We measure the angles of light rays from the normal.

The diagram shows two different angles of incidence, and two angles of refraction, but only one of each is labelled. Label the other angles.




**2** Use the word 'normal' in your answers to this question.

**a** Which way does the light change direction when it goes into the glass block?

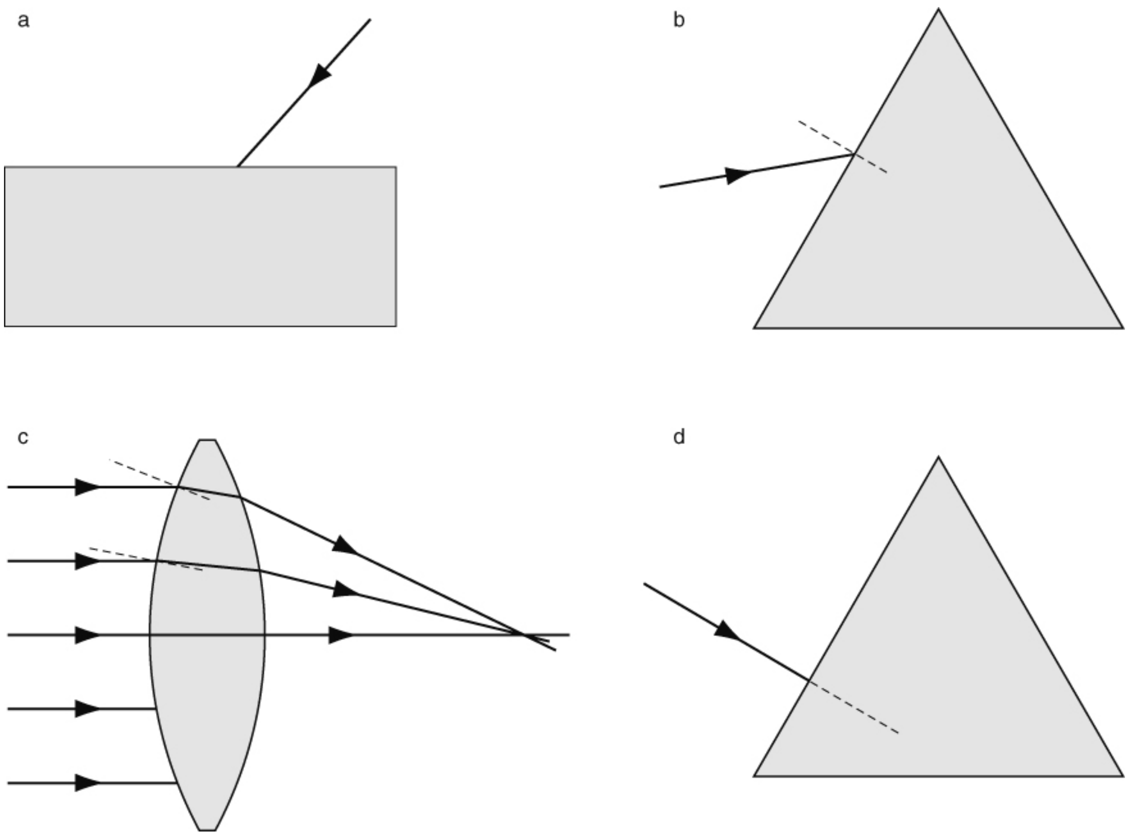
______________________________

______________________________

**b** Which way does it change direction when it comes out of the block?

______________________________

**3** Draw in the missing rays on these diagrams. Remember to draw a normal at each point where the light crosses a boundary between materials. Use a ruler to help you draw the straight lines.

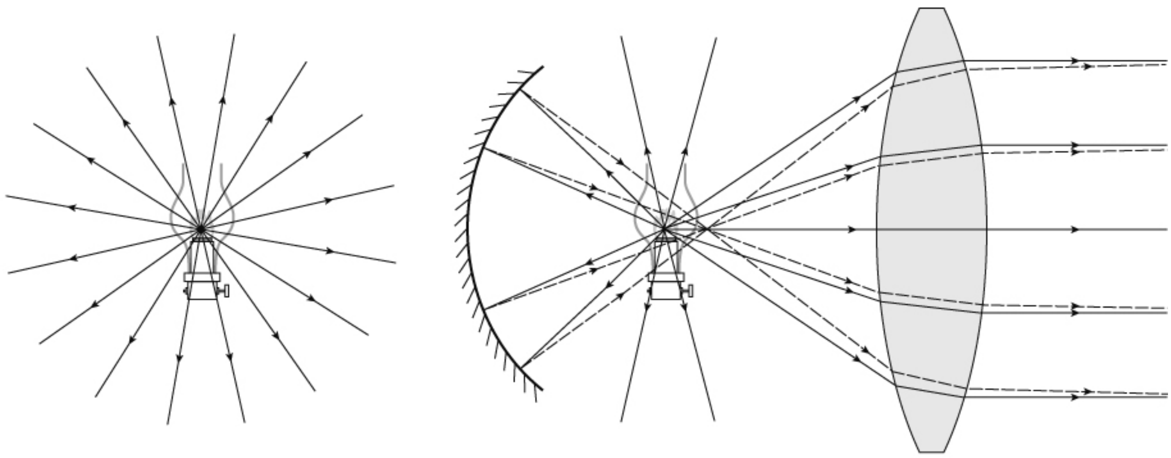



**I can…**

- draw ray diagrams to describe the refraction of light.

# Fresnel lenses

Lighthouses are built to guide ships into harbours, or to warn them of dangerous rocks. The first lighthouses just had a flame – usually from burning whale oil or other fuel. Later it was realised that the light would be visible from further away if the light could be concentrated. The first attempts to do this used reflectors behind part of the flame. The light could be concentrated even better, and so seen from further away, using lenses.

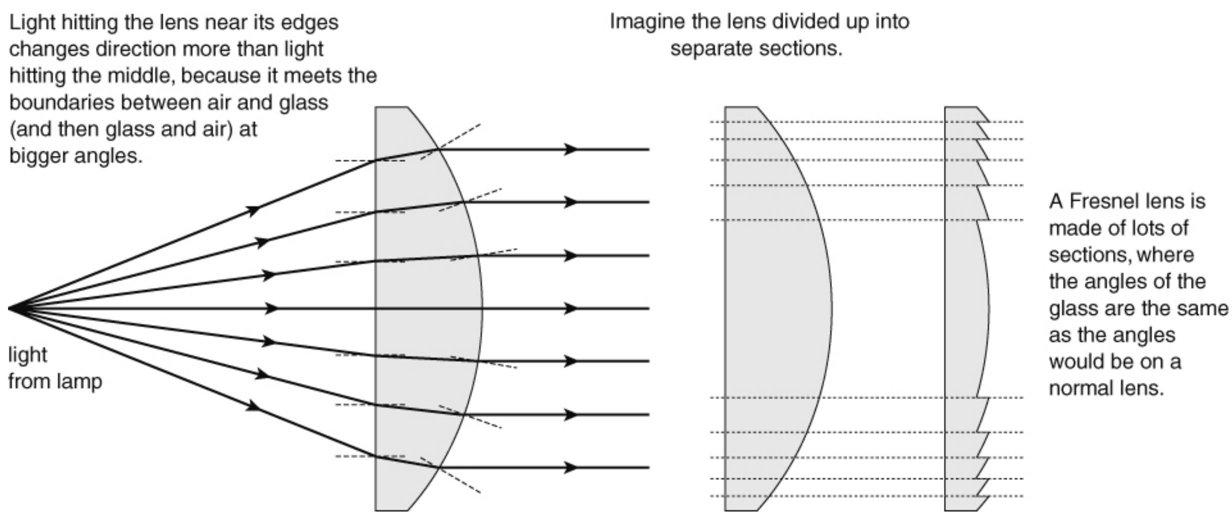


*Light from the oil lamp shines out in all directions.* *With a reflector and lens, almost all the light shines in one direction.*

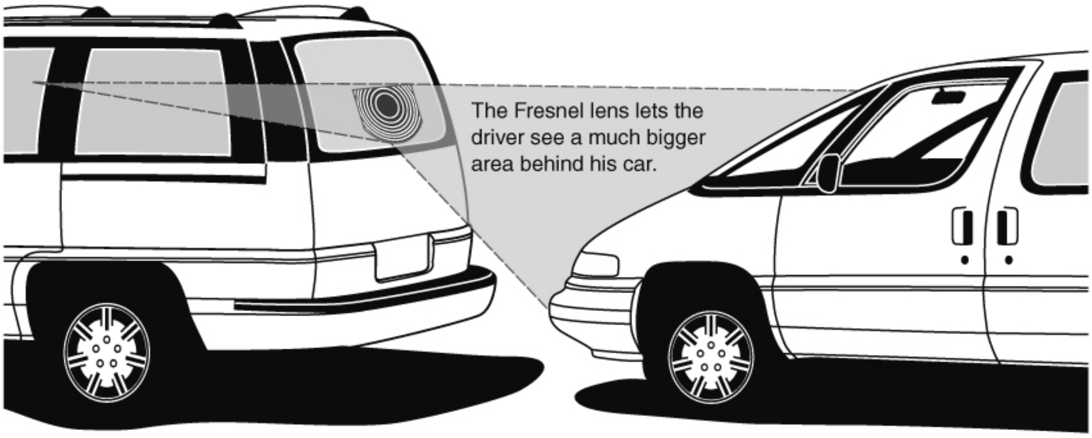
A lens has to be the right shape to change the direction of the light into a beam. If the lens is made bigger, it must also get fatter to keep it the same shape. This means that a lens big enough to work in a lighthouse would be very thick and heavy. The beam would also need to be seen in all directions, so such a lens would have to be moved around the lamp – which would be even more of a problem if it was very heavy.

French physicist Augustin-Jean Fresnel (1788–1827) (pronounced *fray-nell*) came up with a solution. The type of lens he designed is called a Fresnel lens, after him. The first Fresnel lens was used in a lighthouse in France in 1822. A Fresnel lens has the same effect as a large converging lens, but it can be made very thin.

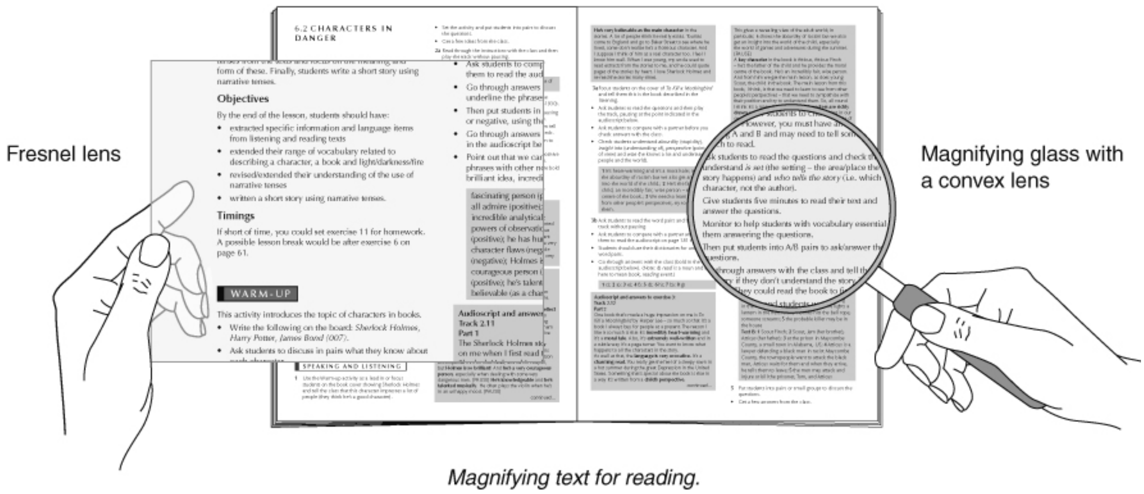
**1** Why didn't lighthouse builders just use smaller lenses that weren't too heavy?




Fresnel lenses can be made from flexible plastic, and have many other uses today.




*Some drivers attach a Fresnel parking lens to their rear window to help when they are reversing into tight spaces.*




*Magnifying text for reading.*

**2** Why do lighthouses need a way of concentrating the beam of light?

**3** **a** What are the advantages of a Fresnel lens for a lighthouse compared to using a single converging lens?

**b** Suggest some possible disadvantages.

**4** **a** How does the parking lens help drivers?

**b** What are the advantages of using a Fresnel lens compared to a normal glass lens?

**c** Suggest why Fresnel lenses are used for parking lenses but they are not used in cameras.

**5** Describe the advantages of using a Fresnel lens for reading, compared to using a normal magnifying glass.

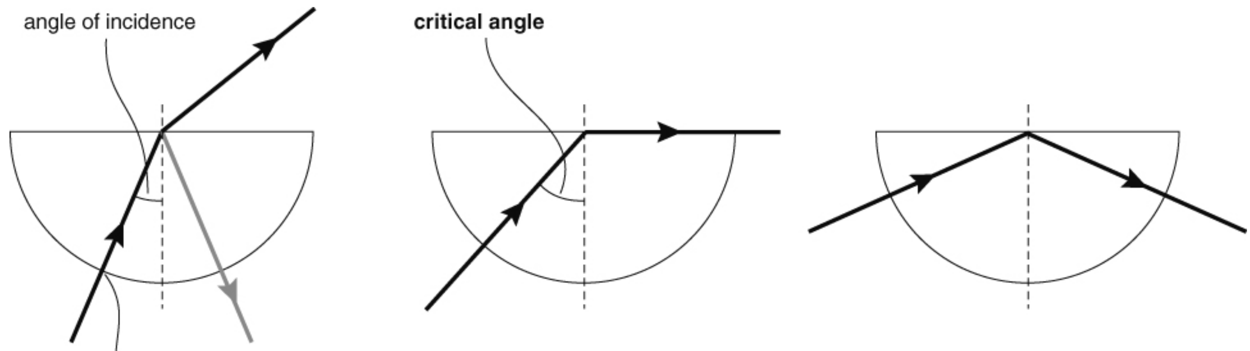
**6** Spotlights used in theatres often have Fresnel lenses to help to focus the beam of light. Suggest some advantages and disadvantages of using a Fresnel lens for this purpose.

**7** Cameras would be much lighter if they used thinner lenses. Suggest why Fresnel lenses are not used in cameras. Draw a diagram to help you to explain your answer.

**I can...**

- describe some applications of lenses
- make comparisons between different types of lens.

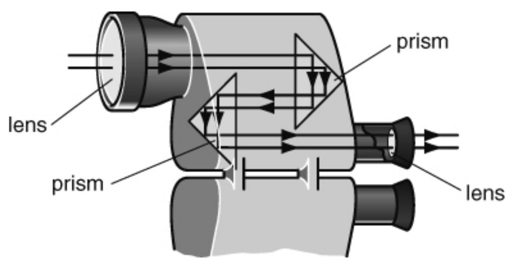
When light rays are transmitted through a glass block, they do not always pass right through the block and back into the air. Sometimes, some of the light is reflected and some of it is refracted.




Total internal reflection can happen whenever light goes from water or glass into air. It has many applications.

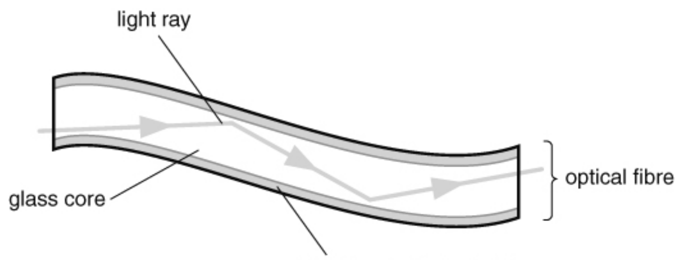
## Telescopes and binoculars

Most telescopes use two lenses to make a larger image, but the image is upside down. Binoculars have two lenses and two prisms. The prisms send the light backwards and forwards twice so binoculars are shorter than a telescope of the same strength. The prisms also make the final image the right way up. Some telescopes have been specially designed for birdwatchers, and these telescopes have arrangements of prisms to turn the image the right way up. Although these telescopes give better magnification than binoculars, they are much heavier and more expensive.




## Optical fibres

Doctors can use glass fibres to see into different parts of the body. Light is reflected from side to side along the glass fibre. When glass fibres are used like this they are called optical fibres.



1 **a** What does total internal reflection mean?

**b** Give *two* examples of where total internal reflection is used.

2 What is the difference between refraction and reflection?

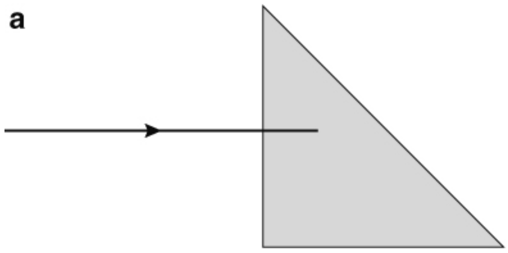
3 **a** Why do bird watchers often use binoculars rather than telescopes?

**b** Telescopes used for astronomy do not have prisms to make the image the right way up. Suggest why this is.

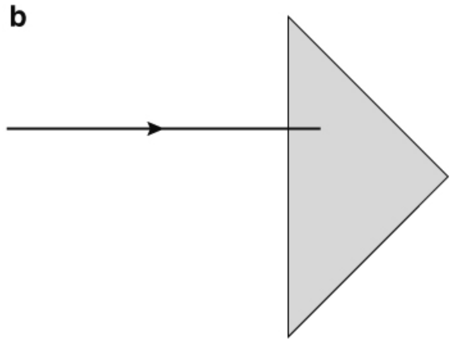
4 Periscopes can be used to see around corners or to see into inaccessible places. Suggest why optical fibres are better than periscopes for medical uses.

5 Copy these diagrams of prisms and finish drawing the light rays. The critical angle for glass is approximately 42°. Use a protractor to help you to draw the angles accurately.

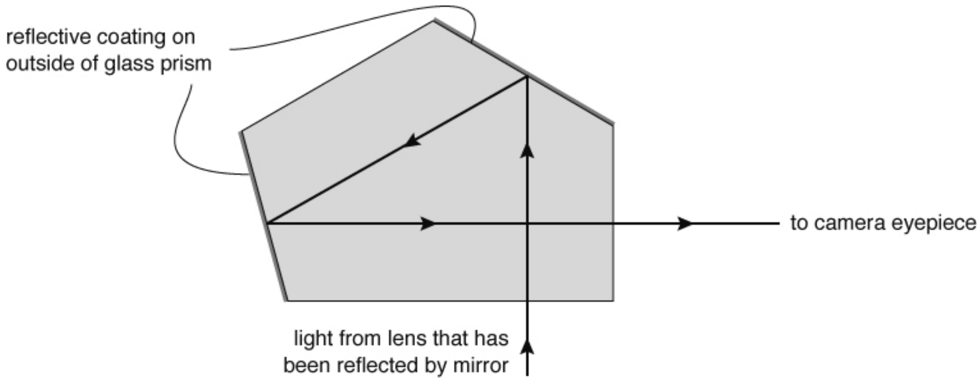
**a**



**b**



6 This diagram shows a pentaprism used in most SLR cameras. It reflects the light from the mirror in the camera through 90° and produces an image in the viewfinder that is the right way up.




**a** Why is a reflective coating needed on the outside of the prism? (*Hint*: look carefully at the angles where the light is reflected.)

**b** Suggest why the camera doesn't just have a single triangular prism, as shown in the diagram in question 5a. It may help you to draw two separate rays of light on the diagram for 5a, and on a copy of the diagram of the pentaprism.

**c** Suggest why the camera does not have two prisms, as used in binoculars.

**I can…**

- explain what total internal reflection is
- describe some applications of total internal reflection.

# Cameras and eyes

Name ______________________ Class __________ Date __________

**1** Solve the clues to find parts of cameras and parts of eyes.

**a** A hole to let light into a camera. ______________________

**b** Detect coloured light. ______________________

**c** Transparent covering of eye that focuses light. ______________________

**d** Coloured part that surrounds pupil.______________________

**e** Focuses light. ______________________

**f** Stores images. ______________________

**g** Change the shape of the lens. ______________________

**h** Takes nerve impulses to the brain. ______________________

**i** A hole in the middle of the iris. ______________________

**j** Changes energy transferred by light into nerve impulses. ______________________

**k** Detect faint light, but cannot detect colour. ______________________

**l** Changes energy transferred by light into electrical signals. ______________________

**m** Protects the sensor when a picture is not being taken. ______________________

**2** Find the words in the grid. If the word names part of a camera, circle it in red. If it names part of an eye, circle it in blue. If the same thing can be found in both, put two coloured lines around it.

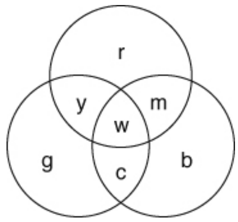
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | P | E | R | T | U | R | E | S | C | L | R | M |
| I | S | O | P | T | I | C | N | E | R | V | E | U |
| P | U | P | I | L | U | C | O | N | E | S | T | S |
| E | S | H | U | T | T | E | R | S | O | E | I | C |
| L | E | N | S | I | R | I | S | O | C | R | N | L |
| R | O | D | S | C | E | C | O | R | N | E | A | E |
| M | E | M | O | R | Y | C | A | R | D | E | U | S |

**I can…**

- state the names of parts of a camera and an eye.

## Introduction

All colours can be made from the three primary colours red, green and blue. We see white light when our eyes detect all three primary colours together. Secondary colours are made when primary colours mix. Use this idea to investigate what happens when you add different colours to a circle of card and then spin it.



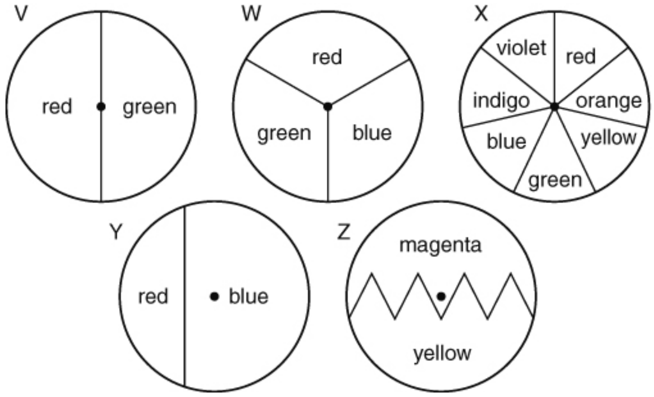

r = red
y = yellow
g = green
c = cyan
b = blue
m = magenta
w = white

## Prediction

1 Which mixture of colours do you think will look nearest to white when spun? Explain your answer.

2 Look at the patterns below and predict what you will see when you spin each one. You could describe your predictions in words or sketches.

## Method




### Apparatus

- compass
- pencil
- scissors
- coloured pens or pencils
- card cut into circles
- a pencil or small motor to spin the circles

**A** Colour in the circles as shown above.

**B** Connect the circles to a motor or spin them by hand.

## Recording your results

3 Put your results in a neat table.

## Considering your results/conclusions

4 Did you produce white from several colours? Which colour combinations made white?

5 Did you produce any secondary colours from primary colours? If so, which colours?

6 Did you produce any primary colours from secondary colours? If so, which ones?

7 Did you notice a particular pattern from your designs when they were spinning? Was this what you expected to find?

## Further work

8 If you have time, make a pattern of your own and predict what will happen before you spin it.

### I can...

- carry out an investigation
- record my results
- draw conclusions and use them to make predictions.

# Light true or false

**Name** ______________________ **Class** ____________ **Date** ____________

These statements are about light, reflection and refraction.
Some of them are not correct.

Tick (✓) the boxes to show if each statements is true or false, and write out a corrected version of the statements you think are false.

Then draw a mouth on the faces to show how sure you are about each of your answers.

I'm sure | Not very sure | No idea!

| | Statement | True | False | How sure? |
|---|---|---|---|---|
| **1** | Light is reflected and scattered by rough surfaces. | ☐ | ☐ | |
| **2** | The normal is a line at 45° to a surface. | ☐ | ☐ | |
| **3** | Light travels at different speeds in different materials. | ☐ | ☐ | |
| **4** | For a mirror: angle of incidence = angle of refraction. | ☐ | ☐ | |
| **5** | The image in a mirror is the same size as the object. | ☐ | ☐ | |
| **6** | Light travels faster in glass than it does in air. | ☐ | ☐ | |
| **7** | Light bends away from the normal when it goes from air to water. | ☐ | ☐ | |
| **8** | Light bends towards the normal when it goes from air to glass. | ☐ | ☐ | |
| **9** | Lenses bend light by reflection. | ☐ | ☐ | |
| **10** | Converging lenses bring rays of light to a point. | ☐ | ☐ | |

**I can…**

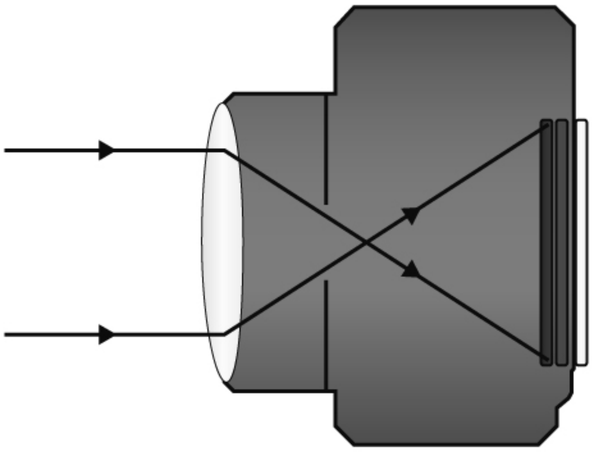
- recall key facts about light, reflection and refraction.

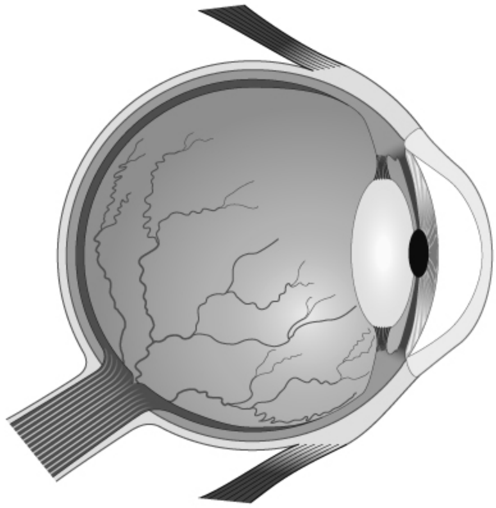
# Camera and eye diagrams

The diagrams show a camera and an eye. Cut out the diagrams and stick them in the middle of a sheet of paper. Cut out the labels and stick them around the diagrams. Draw lines to connect the labels with the parts of the camera and eye.

**I can…**

- describe the parts of a camera and an eye
- describe the functions of parts of a camera and an eye.





| | | | |
|---|---|---|---|
| aperture | cornea | iris | lens |
| lens | muscles | optic nerve | pupil |
| retina | sensor | shutter | |

| | | |
|---|---|---|
| carries nerve impulses to the brain | changes the shape of the lens to focus on close or distant objects | changes the size of the pupil to control the amount of light getting into the eye |
| controls the amount of light getting into the camera | converts energy transferred by light into electrical signals | converts energy transferred by light into nerve impulses |
| focuses light | focuses light | hole in the iris that lets light into the eye |
| stops light hitting the sensor until a photograph is being taken | transparent covering helps to focus light | |

# Using lenses

**1** Diagrams A and B show two pinhole cameras with different sized holes. Finish drawing the rays of light to show how an image is formed on the screen in each camera.

**2** Diagram C shows a pinhole camera with a large hole and a lens. Finish drawing the rays of light to show how an image is formed.

**3** On lined paper, write a short paragraph to explain:

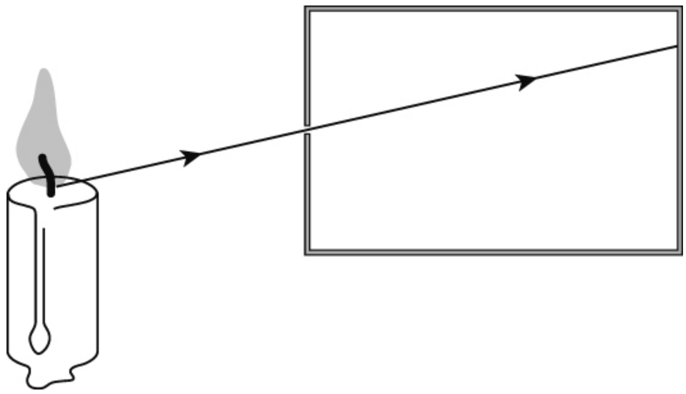
- **a** why the cameras produce an image that is upside down
- **b** why camera B produces a brighter image than A
- **c** why camera A produces a sharper image than B.

**4** Write a short paragraph to explain why cameras need lenses.

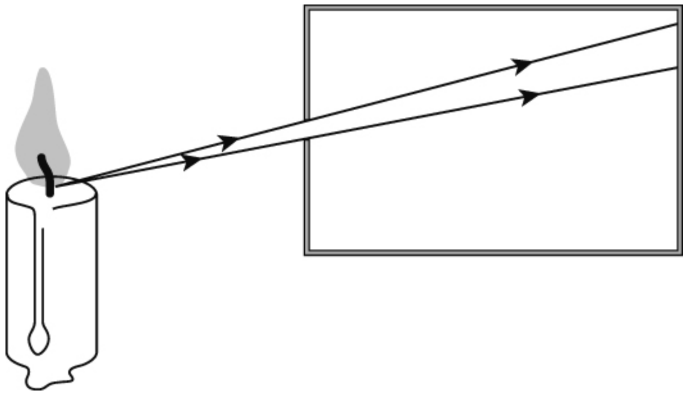
**5** Explain how the lenses in our eyes help us to see.

**6** Cut out your completed diagrams and explanations and stick them onto a piece of paper.

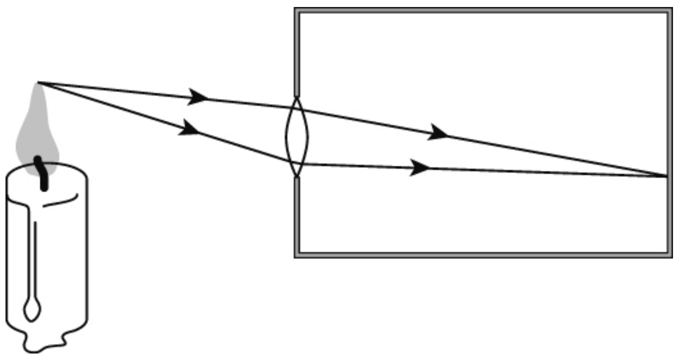
**A**



**B**



**C**



**I can…**

- draw ray diagrams to show the paths of light rays in cameras
- explain why lenses are needed in cameras and eyes.

Use this checklist when you are preparing a presentation.

## Before you start…

### Why are you giving the presentation?

You could be:

- giving information
- reporting research
- trying to persuade people about something.

### Who are you giving the presentation to?

- How much science knowledge do they already have?
- Will you need to explain scientific words?

### How long do you have to give your presentation?

- If you only have a short time, you will have to concentrate on just the most important facts.

## Making visual aids…

Visual aids, such as computer presentations, can help you to decide what to say. They can also help you to remember what you should be saying while you are giving the presentation.

### Visual aids should:

- have text large enough for the audience to read.
- not have too many ideas on each screen.
- use bullet points or tables if possible.
- include diagrams to help you to explain things.

Visual aids should *not* contain the whole script of your presentation!

## Final checks…

Are your facts in a logical order?

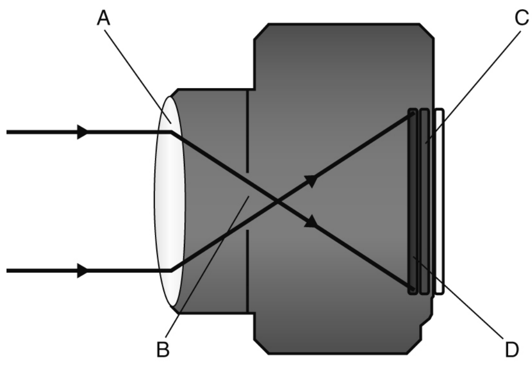
Have you practised your presentation to check how long it will take?

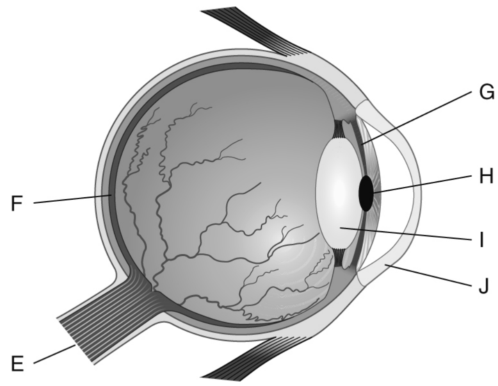
**I can…**

- prepare a presentation using a mixture of text, diagrams, charts and graphs
- choose a suitable method of presenting information for a given audience.

**Name** ______________________ **Class** __________ **Date** __________

The diagrams show a digital camera and an eye.




**1** Write down the names of the parts labelled in the diagrams.

**A** and **I** __________ **B** __________ **C** __________

**D** __________ **E** __________ **F** __________

**G** __________ **H** __________

**2** Which part of the eye or camera:

**a** lets light in __________ **b** focuses light __________

**c** changes the energy transferred by light into electrical signals __________

**d** changes the energy transferred by light into nerve impulses __________

**e** sends nerve impulses to the brain __________

**3** The iris can change size to control how much light gets into the eye. Which of these statements is correct? Tick (✓) *two* boxes.

☐ The iris makes the pupil large if the light is dim.

☐ The iris makes the pupil small if the light is dim.

☐ The iris makes the pupil large if the light is bright.

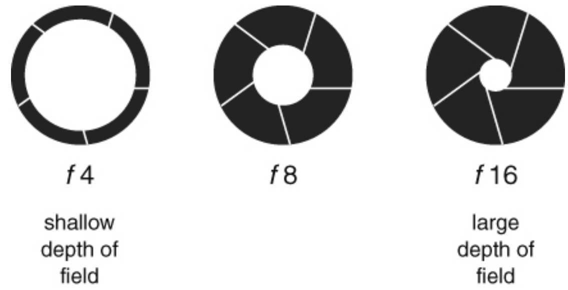
☐ The iris makes the pupil small if the light is bright.

**I can…**

- identify the parts of cameras and eyes
- state what the different parts of eyes and cameras do.

Digital cameras work by changing the energy transferred by light into electrical signals that are then recorded on a memory card. The sensor in the camera needs to receive a certain amount of energy to be able to record an image. The amount of light hitting the sensor is controlled by the size of the aperture and the shutter speed (the length of time that the shutter is open).

Aperture sizes are given f numbers, where the larger numbers mean smaller apertures. A smaller aperture gives a bigger ‘depth of field’, which means that more things in the image will be in focus.




Shutter speeds are given in fractions of a second, so that 1/50 means that the shutter is open for 1/50th of a second. A ‘fast’ shutter speed is when the shutter is only open for a very short time.

A photographer chooses the right aperture and shutter speed settings depending on the type of photo he or she is taking.

**1** A photographer takes a photograph with an aperture of f8, and then takes another with an aperture of f16. The shutter speed is the same.

**a** Explain which photograph will look the brightest.

**b** If she wants to have the same brightness in both photos, explain how she should change the shutter speed for the second photograph.

**2** A photographer is taking a close-up photograph of an insect and wants the background to be out of focus. Explain why he will need to use

**a** a large aperture

**b** a fast shutter speed.

**3** People who photograph motor racing usually use very fast shutter speeds. Suggest why they do this.

**4** **a** How does the human eye control the amount of light that enters it?

**b** How is this similar to the way the amount of light is controlled in a camera?

**c** How is it different?

**5** Refraction occurs in both eyes and cameras. Describe where this happens.

**6** Eyes and cameras can both focus on objects at different distances. Describe how this is done.

**7** A photograph taken at night can show many more stars than a person could see with their eyes. Explain how this is possible.

**8** The sensor in a camera contains lots of small cells. There are three types of cell, each sensitive to a different colour. Suggest what colours they are sensitive to, and why only three colours are necessary.

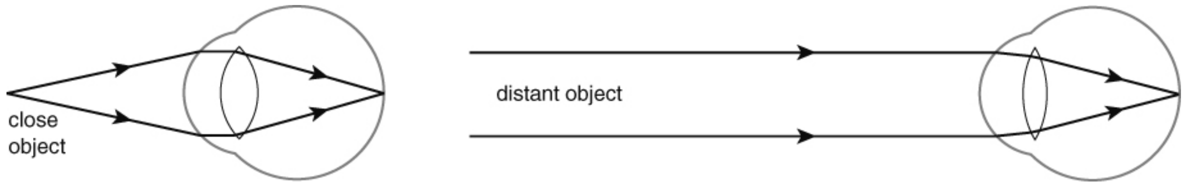
**I can…**

- recall the functions of parts of the camera and the eye
- compare cameras and eyes.

# Eyes and spectacles

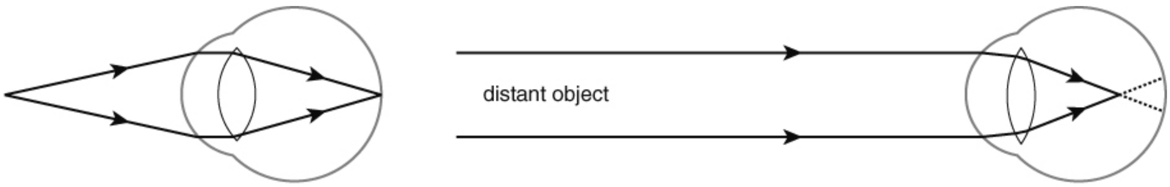
Many people need to wear spectacles because their eyes do not focus light properly. There are two common sight defects, called short-sight and long-sight.

Normally, muscles change the shape of the lens in your eye so that you can focus on things that are close to you or things that are a long way off.



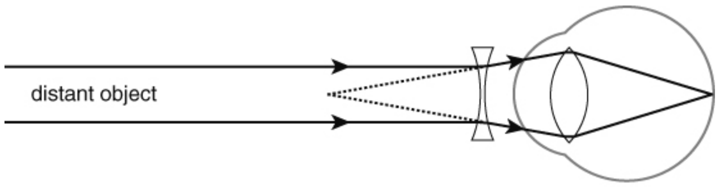

## Short-sight

If you are short-sighted, you can focus on objects that are close to you, but not ones that are a long way off. When you are looking at distant objects, the rays of light are focused in front of your retina (i.e. 'short of' the retina). This happens either because your eyeball is too long, or your lens is too thick.




*Light from close objects is focused on the retina.* *Light from distant objects is focused in front of the retina.*

Short-sight can be corrected by wearing spectacles or contact lenses with diverging lenses. These are lenses that are thinner in the middle than at the edges, and make light spread out.




*The lens makes the light rays spread out, as if they had come from a much closer object.*

## Long-sight

If you are long-sighted, you can focus on distant objects but not close ones. This happens either because your eyeball is too short, or your lens is not thick enough to bend the light enough to focus on your retina.

**1** What changes in your eye when you look at objects at different distances?

**2** If you are short-sighted:

- **a** Which things can you see clearly?
- **b** Which things can't you see clearly?
- **c** Why does this happen?
- **d** What kind of lenses do you need in your spectacles or contact lenses?
- **e** How do these allow you to see everything clearly?

**3** If you are long-sighted:

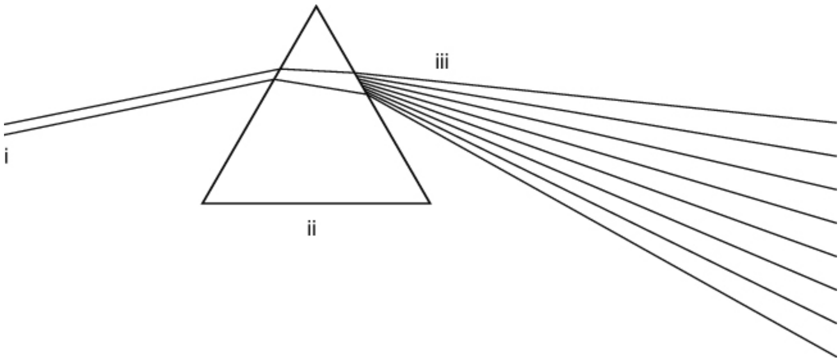
- **a** Which things can you see clearly?
- **b** Which things can't you see clearly?
- **c** Why does this happen? Draw diagrams to help you to explain your answer.
- **d** What kind of lenses would you need in your glasses or contact lenses?
- **e** How would these lenses help you to see everything clearly?

**I can…**

- describe the causes and effects of long sight and short sight.

**Name** ______________________ **Class** ____________ **Date** ____________

**1 a** Colour the diagram using the correct colours.

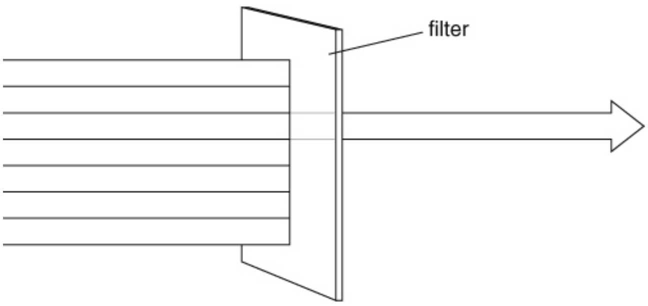



**b** Name the parts:

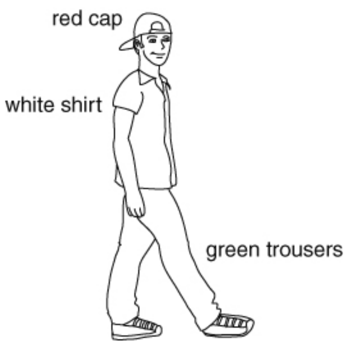
**i** ______________________ ______________________

**ii** ______________________ **iii** ______________________

**2** The filter is yellow. Colour the filter and the light.




**3 a** Joe is in white light. Colour in his clothes.




**b** Joe goes to a club. The light is red. Colour his clothes the colours they appear.

**I can…**

- recall the colours of the spectrum
- recall how a filter makes coloured light
- work out what colour things will appear in coloured light.

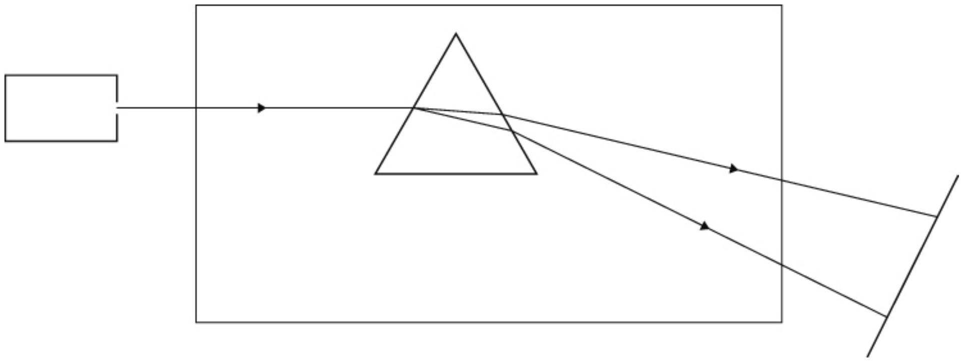
## Aim

To investigate how prisms split light into different colours.

## Method

**Apparatus**
- ray box with slit
- different prisms
- card
- paper
- protractor

⚠ Do not look directly at the bulb or touch it while it is hot.



Copy the diagram and label it using the words from the box.

| angle of incidence | normal | prism | ray box | screen | spectrum |
|---|---|---|---|---|---|

**A** Set up the apparatus as shown in the diagram above.

**B** Adjust the angle of incidence until you have the clearest spectrum. Draw along the edge of the prism and mark the ray of light going into the prism with crosses.

**C** Remove the prism and draw a normal where the light ray meets the edge of the prism. Measure the angle of incidence and write it down.

**D** Repeat steps B and C with other prisms.

## Recording your results

**1** For each prism, what was the best angle of incidence for producing a spectrum?

**2** **a** Is the spectrum the same for every prism?

**b** Are the colours always in the same order?

**3** Does it matter which way round the prism is?

## Considering your results/conclusion

**4** **a** What are the seven colours that white light can be split into?

**b** Which colour was refracted the least?

**c** Which colour was refracted the most?

**I can…**
- carry out an investigation using prisms
- draw a conclusion from my observations.

# Rainbows and glories

You have probably noticed that you only see rainbows when it is a wet or damp day – this is because rainbows are formed when light from the Sun is refracted and reflected inside water droplets.

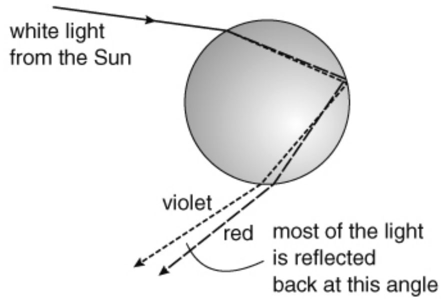
A rainbow isn't something you can touch – you see the bands of colour in the sky because, from where you are, you see only one colour from each drop.

Rainbows always appear in the part of the sky opposite to the Sun. Because they depend on the angles between your eyes and the reflected and refracted light, you will not see exactly the same rainbow as someone standing next to you.

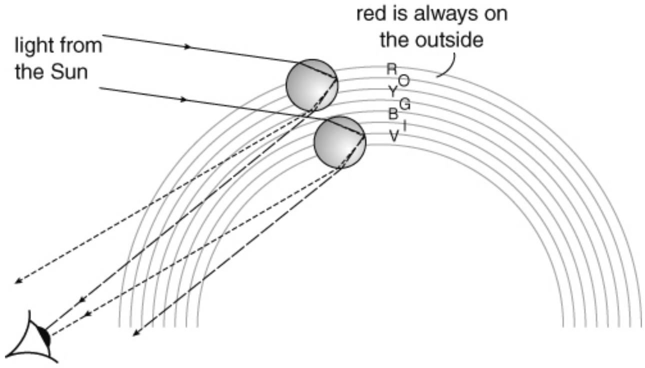
You can see other patterns in the sky that are due to refraction and reflection inside water droplets. If you have ever flown in an aeroplane and looked out at the clouds below, you may have seen a glory (a shadow of the aeroplane with a circle of colours around it).

Hillwalkers sometimes see glories if they are above the clouds or a bank of mist with the Sun behind them. They can see their own elongated shadow with a ring of colours around their heads.

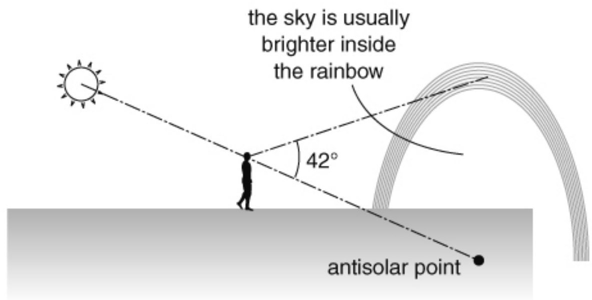
A




B




C




**1** You can see bigger rainbows in the morning and evening, and may not see them at all in the middle of the day in summer. Why is this? Draw a diagram as part of your answer.

**2** Look at diagrams A and B. Why is the sky inside a rainbow usually lighter than the sky around it?

**3** Make a slide for a computer presentation that explains how rainbows form. You could include your drawing from question 1 as part of your presentation.

**4** Work in a group to find out more about refraction and reflection effects. You can use the internet to find pictures of different patterns caused by refraction and reflection. The words in the box will help you to find different effects. Choose one of these effects and make a slide for a computer presentation.

| | | | | |
|---|---|---|---|---|
| rainbow | secondary bow | glory | Brocken Spectre | fogbow |
| | corona | ice halos | | |

**I can...**

- explain why rainbows are not always the same size
- carry out research in a group
- present my research findings clearly.

# Colour questions

**Name** ______________________ **Class** __________ **Date** ___________

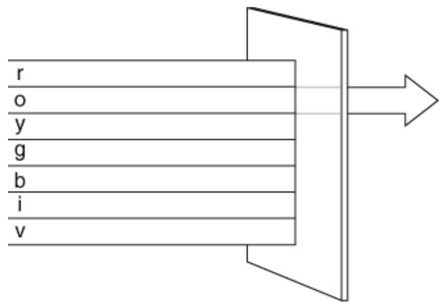
**1** Fill in the gaps in these sentences using words from the box. You can use each word once, more than once or not at all.

| | | | | | |
|---|---|---|---|---|---|
| dispersion | five | lens | prism | reflection | seven |
| spectrum | white | yellow | | | |

Light from the Sun or a light bulb is called _________ light. If white light passes through a _________ it can be split up into a _________. This is called _________. There are _________ colours in the spectrum.

**2** The diagram shows light shining through an orange filter. Complete these sentences using words from the box.

| | | | |
|---|---|---|---|
| absorbs | filter | orange | prism |
| reflects | refracts | transmits | |




You can make coloured light using a ________. This _________ one colour of light and _________ the rest. For example, an ________ filter absorbs all the colours except orange.

**3** A stage in the theatre uses coloured spotlights at different times during the show. The coloured lights make the performers' costumes appear different colours. For example, a white costume looks red in red light because it reflects all colours, but only red light is reaching it. A green costume looks black in red light because it absorbs red light (it only reflects green light).

Complete the table to show what the different parts of the costumes look like. Some have been done for you.

| | **Colour in white light** | **Colour in red spotlight** | **Colour in blue spotlight** | **Colour in green spotlight** |
|---|---|---|---|---|
| **a** | white | red | | green |
| **b** | red | | black | |
| **c** | green | black | | |
| **d** | blue | | blue | black |
| **e** | black | | black | |

**I can…**

- recall how a spectrum is formed
- describe how a filter is used to make coloured light
- work out how coloured light affects the appearance of coloured objects.

# All cats look grey...

There is an old proverb that says that all cats look grey in the dark. If it is really dark you cannot see anything, but you may have noticed that colours do not look the same in moonlight as they do in the daytime. Street lights can also make colours look different.

In the UK, most streetlights used to be 'sodium vapour lamps', which gave out orange light. Now many streetlights are being replaced by different kinds of lights that produce white light. These also use less electricity.

Sometimes coloured lights are deliberately used to change the appearance of objects. For example, coloured lights are often used in theatres to change the appearance of actors or objects on the stage.

**1** Our eyes detect light emitted or reflected from the objects around us.

- **a** Which part of the eye changes energy from light into nerve impulses?
- **b** Why do we have three different types of cone cells in this part of the eye?
- **c** Describe the differences in the way rod cells and cone cells detect light.

**2** Fran is wearing black trousers with a white T-shirt and a blue coat. Explain why her items of clothing appear these colours in daylight. Use the words 'absorb' and 'reflect' in your answer.

**3** Fran goes out at night, in a town with sodium streetlights.

- **a** Explain why her trousers will still look black.
- **b** Explain what colours her T-shirt and coat will appear.

**4** Indoor light bulbs are not as powerful as streetlights, but their light seems brighter because they are closer to the things they are illuminating. Lower powered streetlights could be used if they were put on shorter poles. Suggest why this is not done.

**5**
- **a** Moonlight is white light. Explain where this light comes from.
- **b** Explain why things often look grey in moonlight. (Hint: you need to think about how your eyes detect light.)
- **c** Not all cats will look grey in moonlight. Describe one colour of cat that will always look the same colour, no matter what kind of lighting it is in, and explain your answer.

**6** The bulbs used in theatre spotlights produce white light. Explain how these spotlights can be made to produce coloured light.

**7** A theatre has spotlights that produce red, green and blue light. Explain how some or all of these lights can be used to:

- **a** make a white costume appear red.
- **b** make a white costume appear yellow.

**I can…**

- describe the way our eyes detect colours
- explain why coloured objects appear coloured, and why their appearance changes in different coloured light
- explain how coloured light can be made, and the effect of combining light of different colours.

# Blue skies and sunsets

White light consists of light with a mixture of different frequencies. Each frequency of light has a different wavelength. In the visible spectrum, red light has the longest wavelength and violet light has the shortest.

Photographs of astronauts on the Moon show that the sky there appears black. The skies on Earth can be different colours, depending on how the light from the Sun is scattered by different particles in the air.

When the Sun is high in the sky the light from it is white light. On a day without clouds the sky appears to be blue. Molecules of oxygen and nitrogen in the atmosphere scatter the blue wavelengths in white light more than the colours with longer wavelengths. These molecules are much smaller than the wavelengths of light.

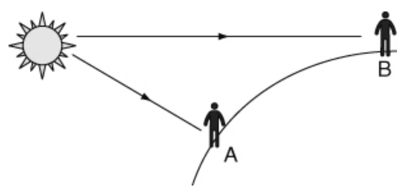
Very red sunsets are due to particles of dust in the air, or to particles of salt if the Sun is setting over the sea. These particles are much larger than gas molecules, and are good at scattering the longer wavelengths of visible light.

**1** Objects form shadows on sunny days, but you can still see objects that are in the shadow of something else.

- **a** Explain how this shows that sunlight is scattered in the atmosphere.
- **b** Explain how this shows that *all* light is scattered in the atmosphere, not just blue light.
- **c** If all the wavelengths of light are scattered, why does the sky appear blue?

**2** A thin layer of cloud appears white. Suggest how the clouds are scattering the different wavelengths in the light coming from the Sun.

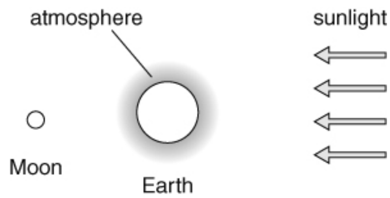
**3** The Sun often appears more yellow, or even red, when it is about to set, even if there is no dust or salt in the air. Use the diagram on the right to help you to explain this.




**4** Why might you expect the sky to look violet rather than blue on a clear day?

**5** A lunar eclipse occurs when the Moon moves into the shadow of the Earth. When this happens the Moon is not usually completely invisible, but often looks dark red.

- **a** Explain where the light has come from that allows us to see the eclipsed Moon. Copy and complete the diagram on the right to help you to explain.
- **b** Explain how this shows that light is refracted by the Earth's atmosphere.
- **c** Suggest why the eclipsed Moon looks red, rather than white or blue.




**6** Optional extra: Find out why photographs taken on the surface of Mars often show the sky as red.

**I can…**

- apply my knowledge of light and colour to explain atmospheric effects.