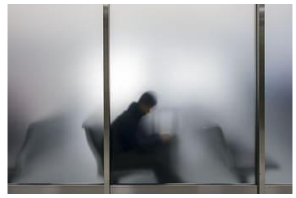
NAME:	SET:

YEAR 9

LIGHT AND SPACE

2023

9P - 1a Review of Light

 Moon	 Brick	 Frosted glass	 Light bulb
 The Sun	 Glass window	 Milk	 Mirror

1 Which one object above is transparent?

………

2 Which objects above are translucent?

………

3 Which objects above are opaque?

………

4 Which object is the best at reflecting light?

………

5 Which object is the best at absorbing light?

………

6 Which object is seen because it reflects sunlight?.

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7 Which object is a light source when it is switched on?

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……………………………………………………………………………………………………

8 Is the sun an example of a luminous or non-luminous object? …………………………...

Why is the sun luminous? : ………………………………………………………………..

9. Is the moon an example of a luminous or non-luminous object? ………………………..

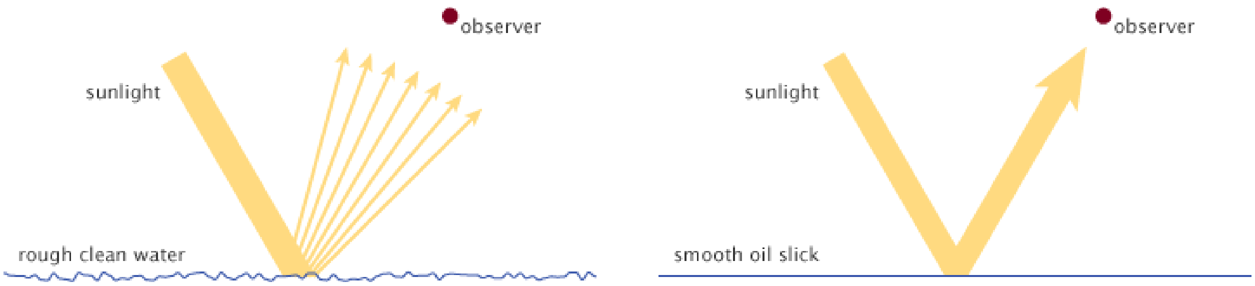
Explain: ……………………………………………………………………………………….

10. Extension: Draw a diagram to show how shadows are cast on the surface of the Earth during a solar eclipse. Explain or label why this happens.

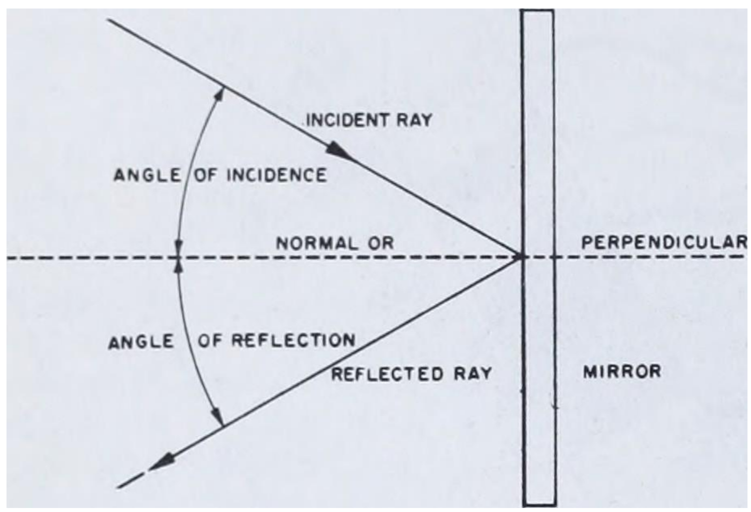
9P - 1b Investigating Reflection

Smooth or Rough?

Is your skin smooth or rough? It may seem smooth to your touch, but for light even apparently smooth surfaces are rough and SCATTER light.



You are going to find out if there is a relationship between the **angle of incidence** and the **angle of reflection** for a smooth surface like a plane mirror.



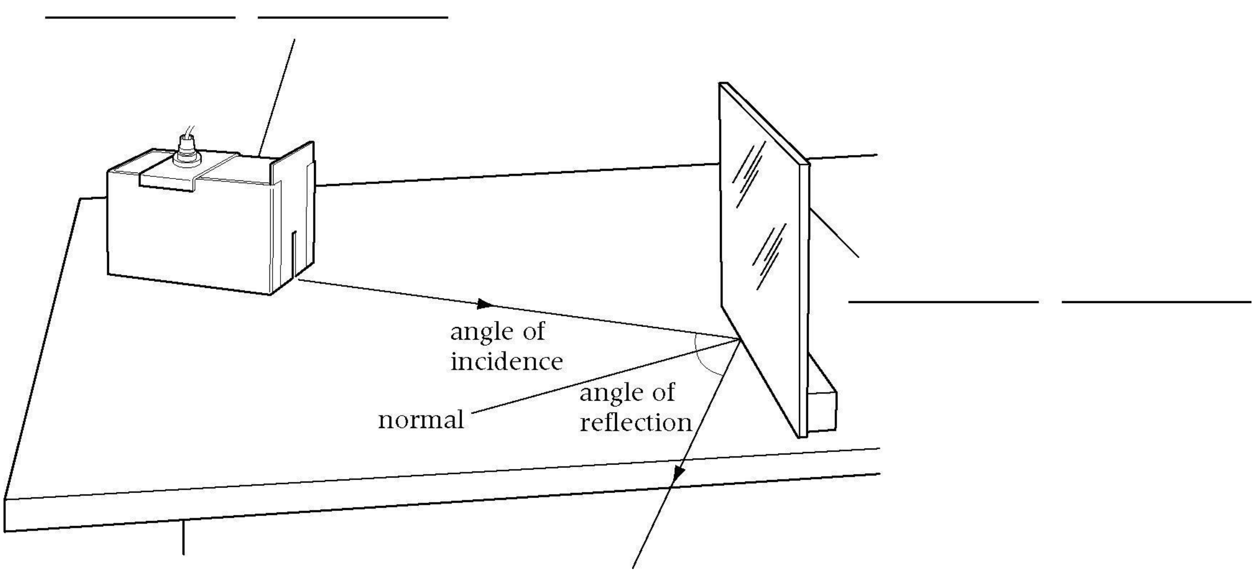
Prediction

I think the angle of reflection will be ____________________ (smaller than / greater than / the same as) the angle of reflection.

Label the diagram using words from the apparatus list.

Apparatus

- **Ray box**
- **Plane mirror**
- **Pencil**
- **Ruler**



<u>Method</u>

1. I will find out what the relationship is between the angle of incidence and the angle of reflection.
2. Using a piece of paper, I will mark down the position of the mirror.
3. I will use a protractor to measure a 90^{o} line to the plane mirror. This line is called the normal and is drawn with a dotted line.
4. I will shine a ray of light onto the mirror using the ray box and label this the Incident Ray.
5. I will draw the position and label the reflected ray.
6. I will use a protractor to measure the Angle of Incidence and the Angle of Reflection, remembering that these are measured FROM THE NORMAL and not from the surface of the mirror.
7. I will record the two and angles in the table.
8. I will then repeat this for 4 different angles of incidence.

Watch this video if you cannot do the experiment at home

https://www.youtube.com/watch?v=V0Z_nk5JS_E

Results

Angle of Incidence in ° (Angle at which light hits the mirror)	Angle of Reflection in ° (Angle that light is reflected at)

Conclusion

I noticed that the angle of incidence is _____________________ the angle of reflection.

This is the Law of Reflection

Extension: (Evaluation)

1. What were the main errors in this practical?

……

……

2. How could you have made this practical more accurate?

……

……

3. How could you use these principles to make a periscope? Find out how periscopes work and draw out a periscope design.

9C - 1c Where is the Image in a Plane Mirror?

1 Hold a plane mirror and look at yourself. Is the image that you see of yourself bigger, smaller or the same size as you?

…………………………………………………………………………………………………

………………………………………………………………………………………………..

2 Is the image that you see of yourself nearer to the mirror, further away or is it the same distance behind the mirror as you are in front of the mirror?

…………………………………………………………………………………………………

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3 Now <u>move away</u> from the mirror. How does the image appear to move?

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…………………………………………………………………………………………………

4 Now move <u>towards</u> the mirror. How does the image appear to move?

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5 a) Write your name a piece of scrap paper. Use the mirror to look at the image of your name. Draw what it looks like in the space below.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

b) Is the image of your name upside down or the right way up? Is the image back to front? (Extension: Find out what this is called. (Clue; L…………. I…………….))

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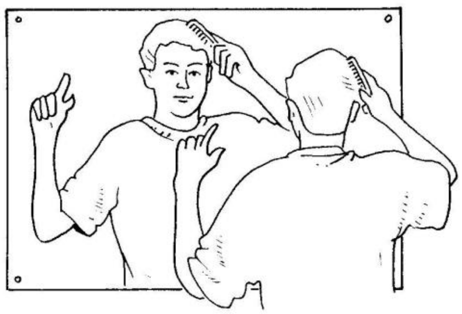
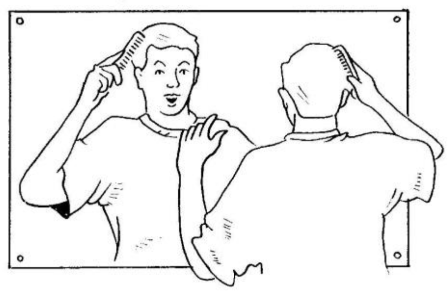
…………………………………………………………………………………………………

c) Which image is correct? Can you explain why?





4 Complete these sentences.

A flat mirror is called a ________________________ (plane/plain) mirror. When a ray of light hits the mirror it is ________________________ (deflected/reflected). You see a reflection in the mirror called an _____________________ (image/picture). The image in the mirror is ________________________ (bigger than/smaller than/the same size as) the object. The image appears to be ________________________ (nearer/further away from/the same distance from) the mirror as the object.

You cannot see an ________________________ (image/picture) using a rough surface like paper. This is because light ________________________ (rays/streams) hitting the paper are ________________________ (scattered/absorbed) in all directions.

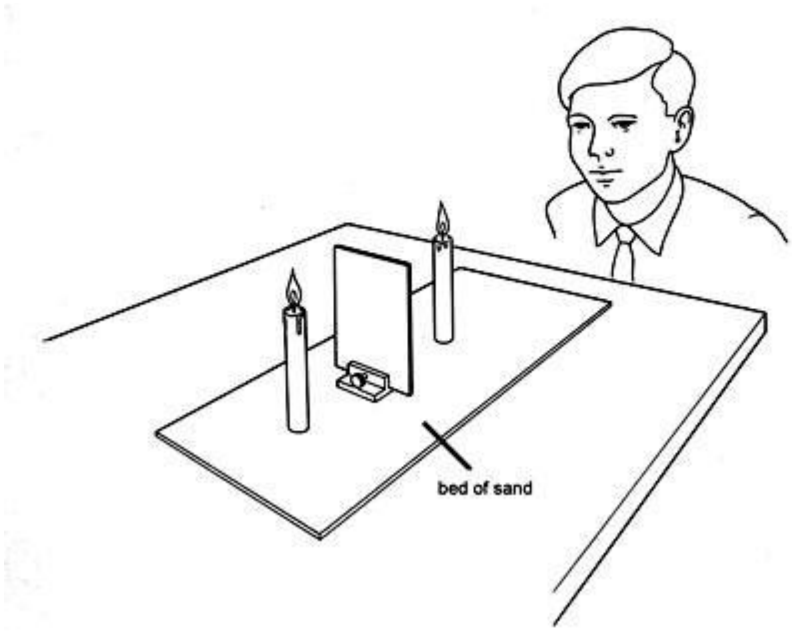
Extension: The image also seems to swap left and right.

This is called ____________ _____________.

Where is the Image in a plane Mirror?

A sheet of plane glass can act as a ‘two way mirror’.

Can you light one candle but make it look like both candles are lit?



How are the positions of the lit and unlit candles related?

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What happens when the lit candles moves closer and further from the glass?

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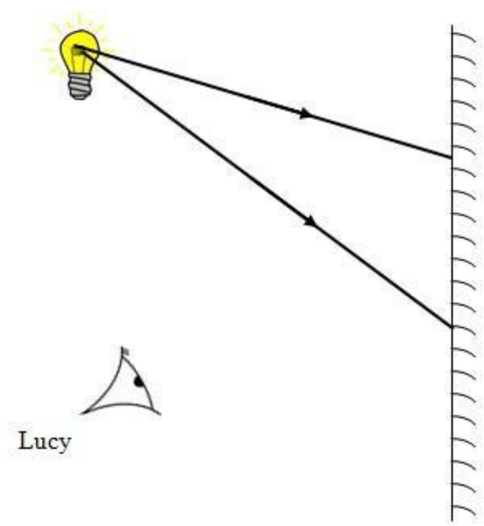
Ray Diagram to find the Position of the Image in a Ray Diagram



1. Draw the reflected ray for both incident rays. Make sure the angles are correct, use your protractor and don't forget the normals!
2. Now extend the rays backwards behind the mirror using dotted lines (these are called 'construct rays'). This is where the light reaching Lucy appears to come from!
3. The image is where the dotted lines meet! Mark this as position I.
4. Now measure how far behind the mirror the image is compared to how far the light bulb is in front.

Conclusion

The image in a plane mirror is the same ………………. behind the mirror as the

…………………. is in front of the mirror.

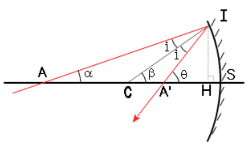
The image is …………………. This means the light is not really there it just looks like it is there!

(We use the same word for " …......... reality" in computer games. It looks real, but it is not real)

9P - 1d Ray Diagrams for Curved Mirrors

Use the ray boxes to give multiple rays and see how the curved mirrors reflect light.

<u>Concave mirror</u>

<table>
<tr>
<td>

A concave mirror curves in (like a cave goes into a cliff)</td>
<td>Draw around the inside of your mirror ‘hatch’ the outside.
Draw your 3 parallel incident rays and the reflected rays.</td>
</tr>
<tr>
<td colspan="2"><u>Conclusion</u>

A concave mirror will cause parallel light to …………………. (converge / diverge)

What are the uses of a concave mirror?

……………………………………………………………………………………………

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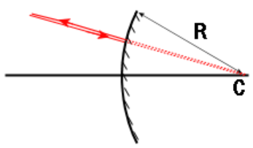
</table>

<u>Convex mirror</u>

<table>
<tr><td>

A convex mirror curves outwards</td><td>Draw around the outside of your convex mirror ‘hatch’ the inside. Draw your 3 parallel incident rays and the reflected rays.</td></tr>
<tr><td colspan="2">Conclusion

A convex mirror will cause parallel light to ……………… (converge / diverge)

What are the uses of a convex mirror?

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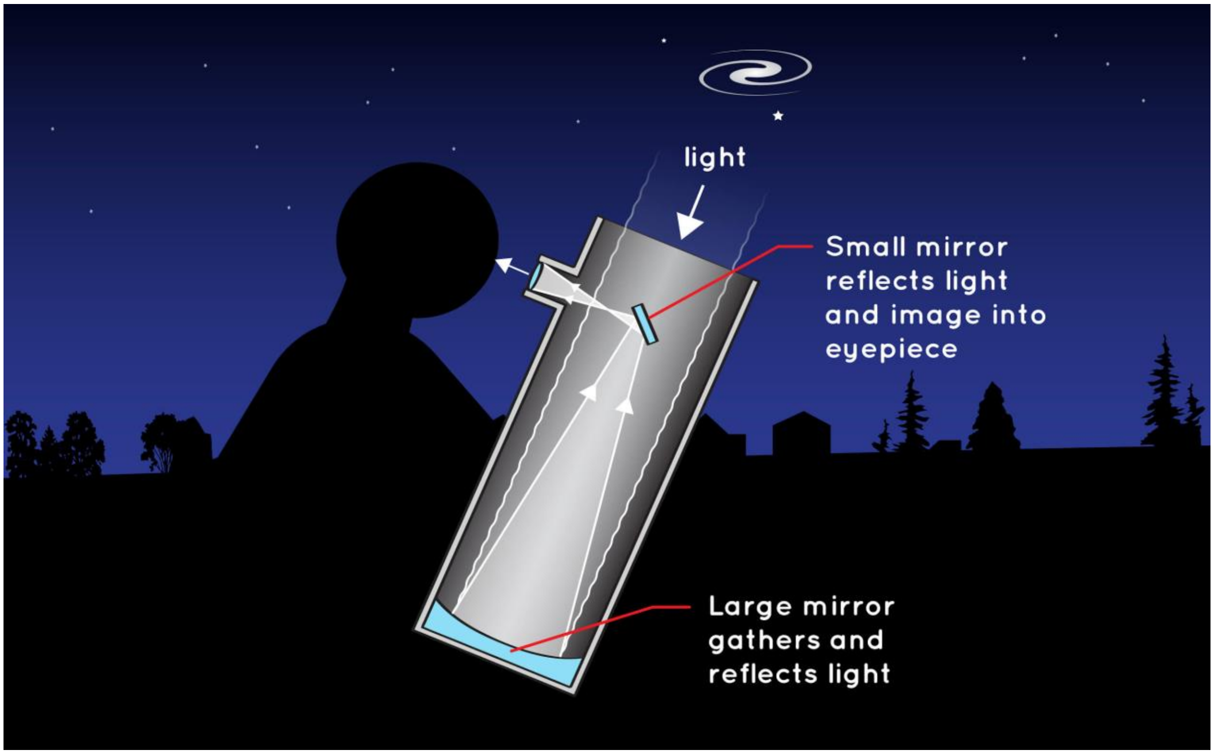
</table>

The Reflecting Telescope.



Light from distant objects like the moon arrives ……………….. (parallel / at random angles)

A reflecting telescope uses a ………….……….. (convex/concave) mirror

to ……………..…… (converge / diverge) the light so that the small plane mirror can reflect it towards our eye.

9P - 1e How do we use mirrors?

Why does the ambulance have the sign reversed?

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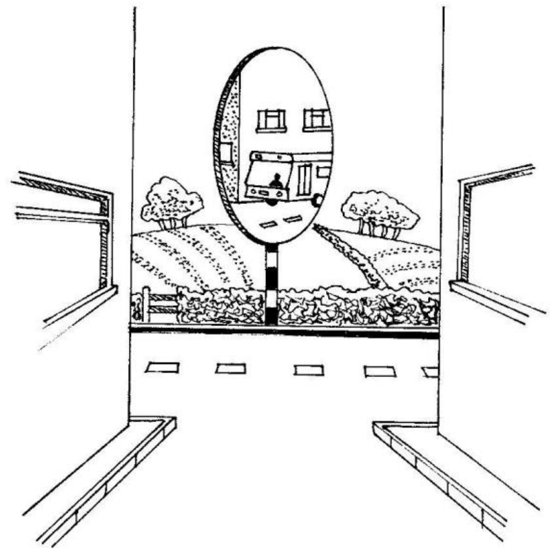
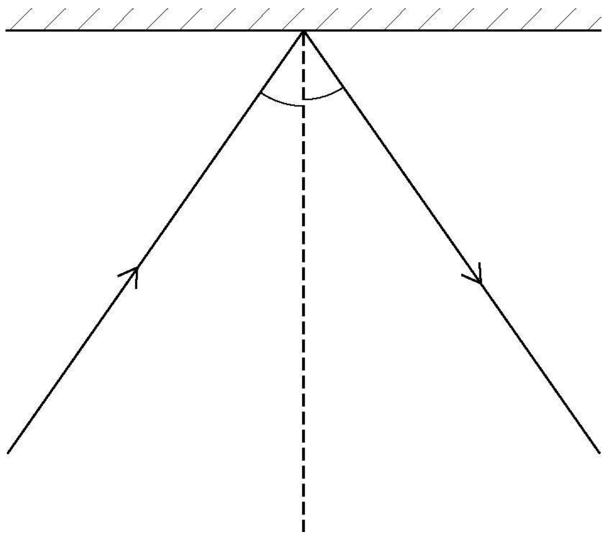


Why is the mirror helpful?

....

....

....



a Use the words from the box to label this diagram.

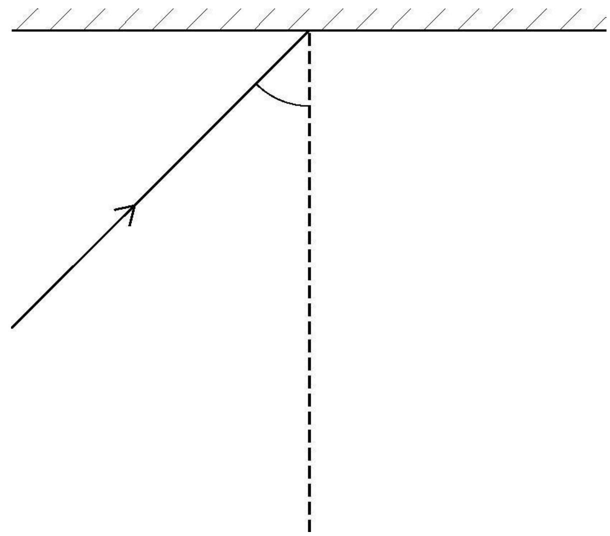
normal **plane mirror**
angle of incidence
angle of reflection

b Measure the angles in the diagram using a protractor and write the answers down.

……………………………………………

……………………………………………

……………………………………………



Measure the angle of incidence on the diagram. Use a protractor to draw in the angle of reflection at the correct angle and label this angle on your diagram.

Extension: Find out what is meant by a ‘**virtual’** image compared to a **‘real’** image.

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Is the image in a plane mirror virtual or real?

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Is the image in a camera virtual or real?

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9P 2a Refraction

<u>Introduction</u>

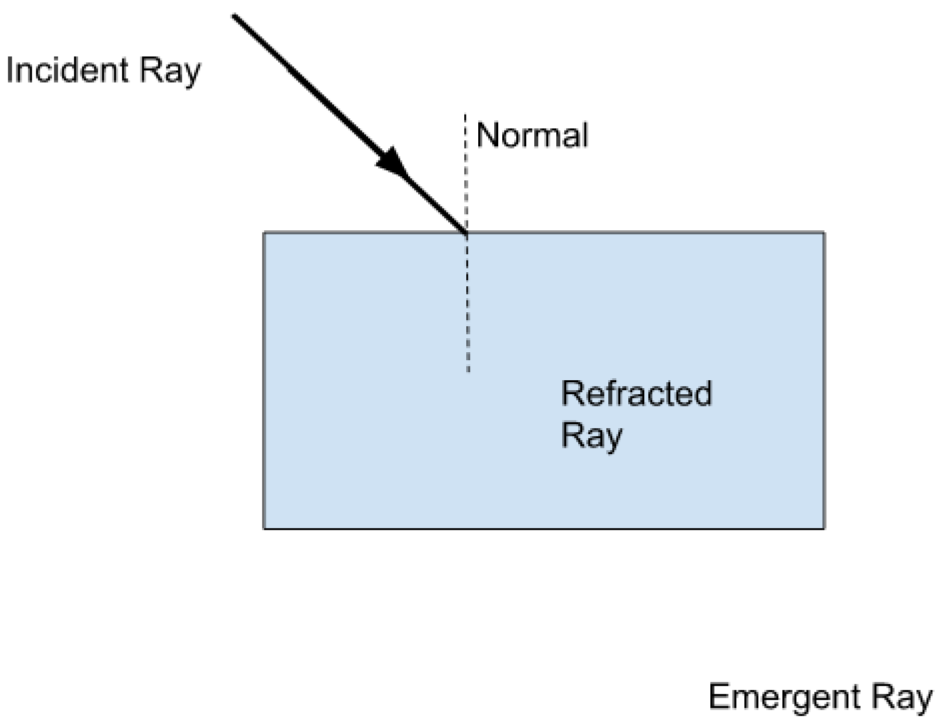
All waves can refract.

Refraction is caused by a change of **<u>medium.</u>**

When light changes its medium (*the material it is travelling through*) it **<u>refracts</u>** and changes **<u>direction</u>** because the light has changed its **<u>speed.</u>**

<u>Experiment 1 - Investigating Refraction</u>

1. Get a glass block and draw around it on paper. This can be in the space on the following page, graph paper or plain paper.
2. Draw in a normal, just to the left of the centre of the block as shown below.
3. Shine a ray of light into the glass block and label it the 'incident ray'. Add arrows to show where the ray refracts and emerges.



Experiment 1 - Space for drawing.

Conclusion (circle the correct response in brackets)

•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.

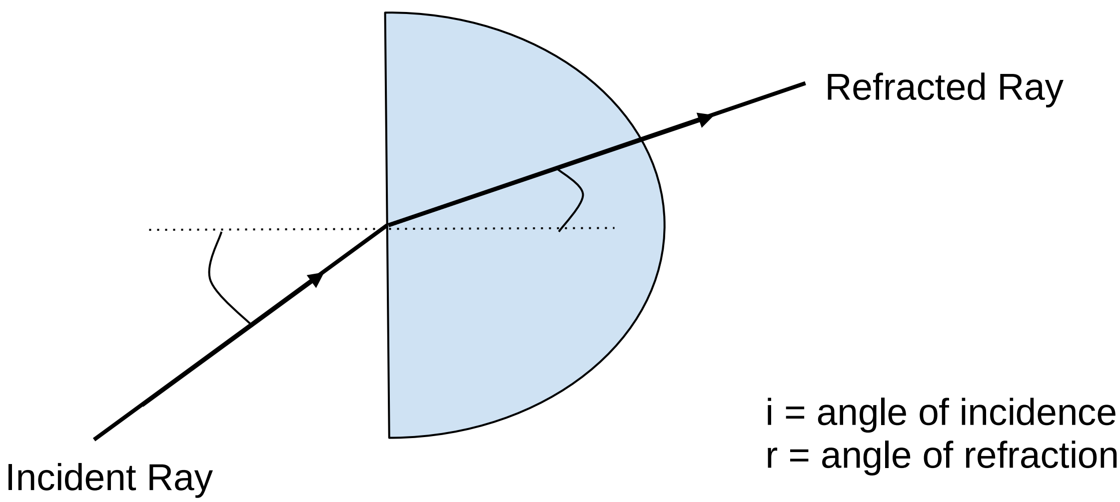
•The ray coming out of the glass block is *(parallel / at right angles)* to the ray going into the block.

<u>Experiment 2 - Investigating the relationship between the angle of incidence and the angle of refraction</u>

<u>Aim</u>**:**

To establish a relationship between the **angle of incidence** and the **angle of refraction** for a semi-circular glass block.

1. Get a semi-circular glass block and draw around it on paper. This can be in the space on the following page, graph paper or plain paper.
2. (on the next page).
3. Draw the normal in the centre of the flat edge of the block as shown below.
4. Shine a ray of light into the glass block at 10^0 to the normal line.
5. Note where the refracted ray leaves the circular side of the glass block by making a mark with a pencil.
6. Draw the path of the refracted ray by connecting the points where it entered and exited the glass block.
7. Use a protractor to measure the angle of refraction.
8. Repeat steps 3-6 for angles of incidence of 20^0 , 30^0 ,40^0 , 50^0 , 60^0 , 70^0 and 80^0.



Experiment 2 - Space for drawing.

Results

Angle of Incidence (^{0})	Angle of Refraction (^{0})
10	
20	
30	
40	
50	
60	
70	
80	

Data Processing

Draw an appropriate line graph of your results. Here are a few things to consider:

- Heading, labels with units on each axis
- Suitable scales that occupy minimum ¾ of each axis
- Plot all points accurately
- Draw a curve or straight line of best fit that ignores points that do not fit the pattern.
- Discuss trends or patterns observed in the graph.

Conclusion

(What is relationship between the angle of incidence and the angle of refraction?)

____

____

____

____

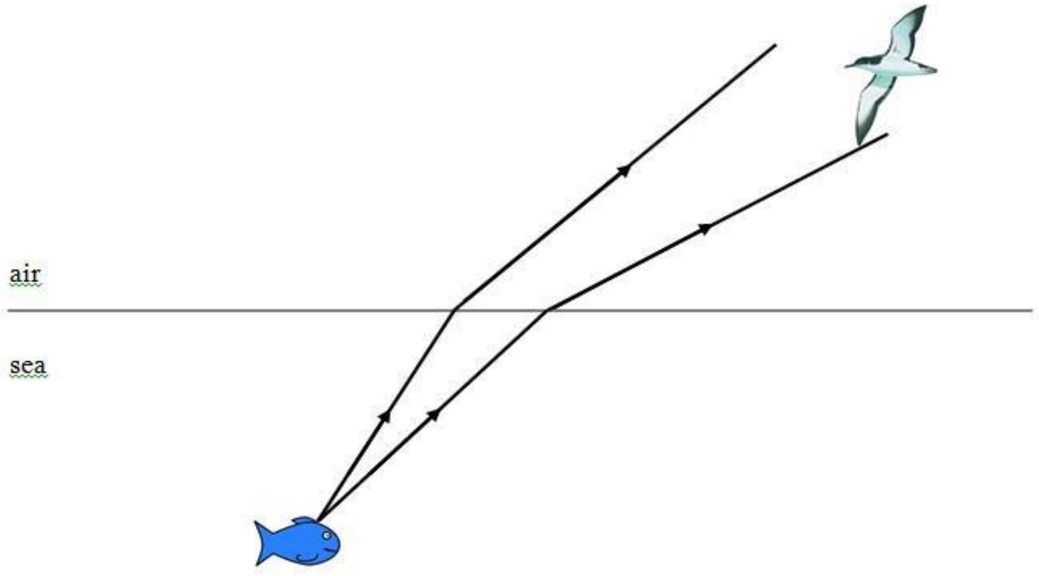
9P 2b Effects of Refraction

Apparent Depth

Watch the first 2min45s of following video on REAL and APPARENT DEPTH:
Real and Apparent Depth

https://www.youtube.com/watch?v=KgZWf5WECq4

1. A shearwater is looking for a fish to catch. Light from the fish refracts as it leaves the water.



From the shearwater's point of view where does the fish appear to be? Follow the rays backwards with dotted lines to where they meet, this is where the fish appears to be!

The distance between the surface of the water and where the rays meet (the image) is called the APPARENT DEPTH. The distance between where the object actually is and the surface of the water is called the REAL DEPTH.

The fish appears to be …………………… (shallower / deeper) that it really is.

This is called APPARENT DEPTH. To catch the fish the shearwater would have to

dive ……………………… (above / below) where the fish appears to be.

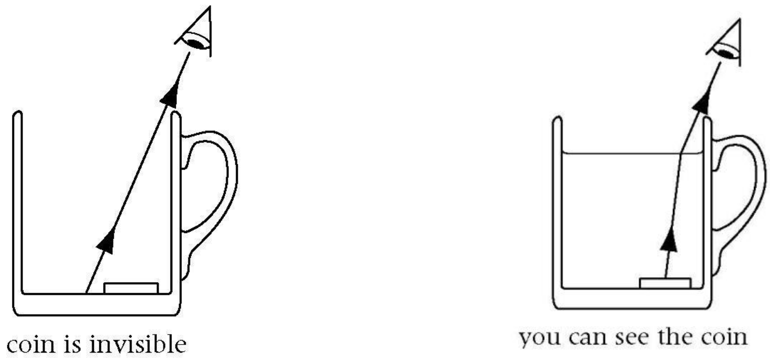
2.

The goggles in the pool appear to be _______________ (deeper / shallower) than they really are.

This is because light rays change _______________ (direction / curve) when they leave the water.

We call this __________________ (reflection / refraction).

3. Coin in a cup.



Explain how this trick works.

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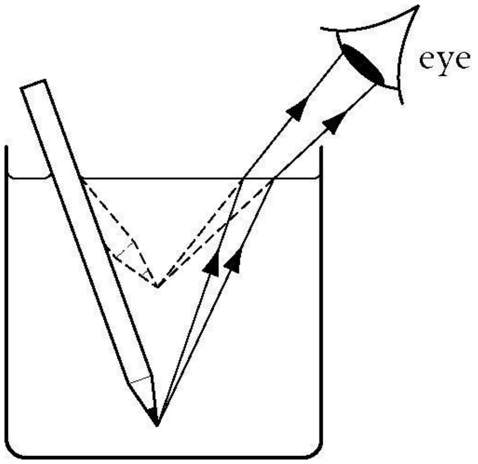
4. This diagram shows what happens to light which is reflected by the pencil.



a) Does the pencil seem to be deeper or nearer the surface of the water?

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……………………………………………………………………………………………………

……………………………………………………………………………………………………

b) Explain why the pencil appears to bend.

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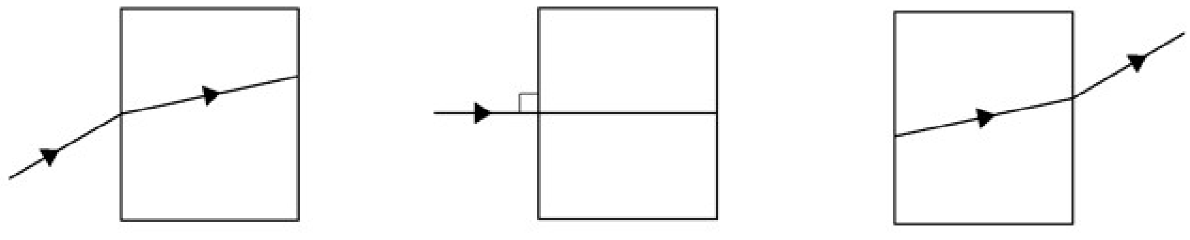
5. Add the missing ray to each glass block.

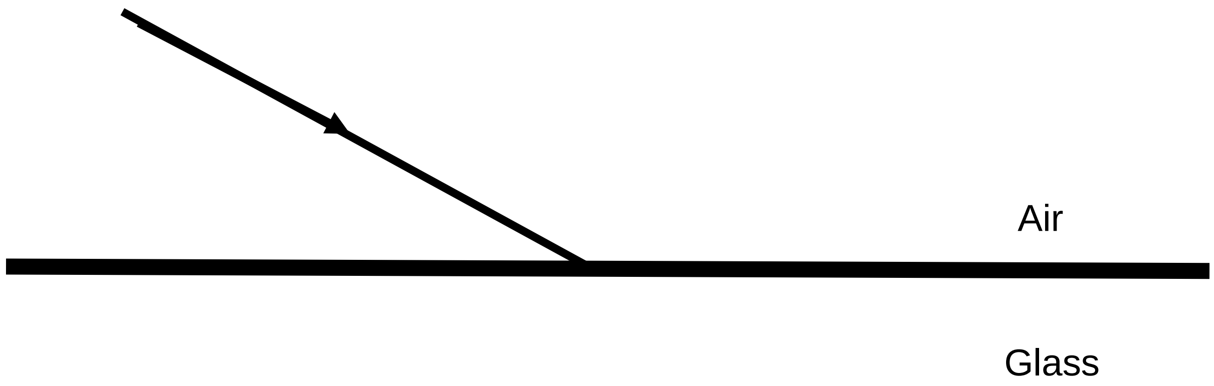


6. Draw a ray diagram below and include the following labels

a) The normal

b) The angle of incidence

c) The angle of refraction



Remember to draw the normal with a dotted or dashed line

7. a) Which is denser, glass or air?

b) How does the density of the material affect the speed of which light travels through it

Extension:

8. What causes refraction of light? Try to explain in terms of the speed of the light. You can draw diagrams or use comparisons/analogies to help you.

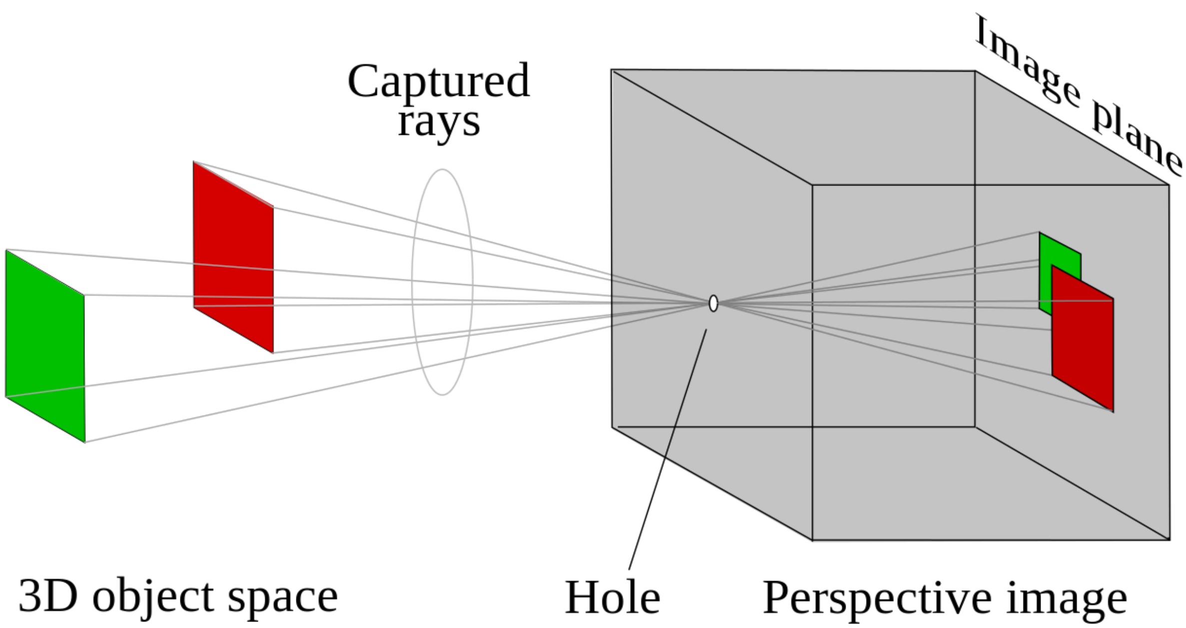
9. Why do stars 'twinkle'?

9P - 3a Investigating Pinhole Cameras

Apparatus	**Safety**
• **Pinhole camera** • **Strong light source** (lamp) • **Weak light source** (Candle)	**Do not look directly at the Sun.** **It will damage your eyes.**

How does a pinhole camera work?

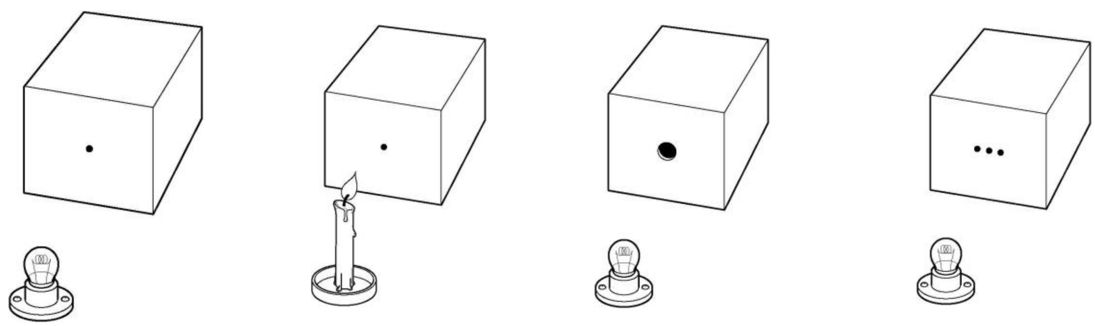
Light passes through the pinhole and an image is seen on the screen at the back



Method

Carry out these investigations. Before you begin, discuss and predict what you think may happen and why.

Prediction:	**Prediction:**	**Prediction:**	**Prediction:**



Record your observations under each diagram

Observations:	Observations:	Observations:	Observations:

Conclusion

- The image in a pinhole camera was …………….. (Real / Virtual)
- The image in a pinhole camera was …………….. (upright / inverted)
- The image in a pinhole camera was …………….. (magnified / diminished)

Questions

1 What is the difference between the images formed by a dim and a bright light?

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…………………………………………………………………………………………………

2 What effect did changing the hole size have on the image?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

3 What happened when you changed the number of holes?

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4 Why does this experiment give evidence that light travels in straight lines?

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Extension - Nature of Science

What is a ‘camera obscura’ and what was its influence on **art**?

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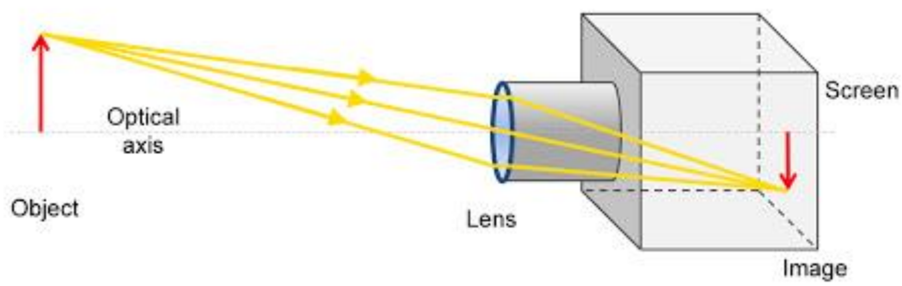
A Simple Lens Camera:

When the pinhole camera had a large hole the image was ………………… (brighter / dimmer) , but also became ……………. (sharper / blurred) .

Can a lens be used to focus the image and make it sharper?



Experiment with Lens Cameras

1. Try some of the different **convex lenses** available and see which one works best. Place the different lens in front of the aperture (hole). Does one create a focussed image?

Compare the length of the pinhole camera to the focal length of the lens which works best.

2. What can you do to help focus the image? Is this how real cameras focus?

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3. Describe how the image appears using any appropriate words below

(**do <u>not</u> use all the words**):

(light, screen, image, upright, focussed, lens, inverted, left to right, real, virtual, enlarged, diminished, magnified)

……………………………………………………………………………………………………

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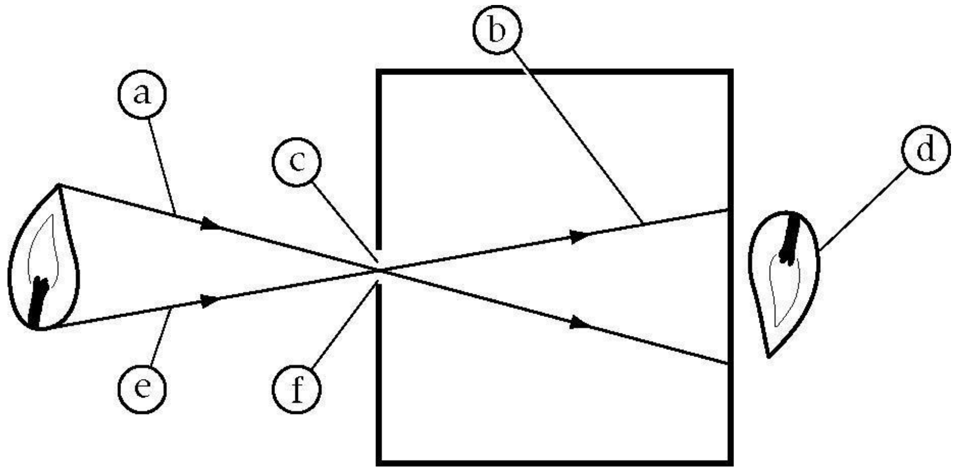
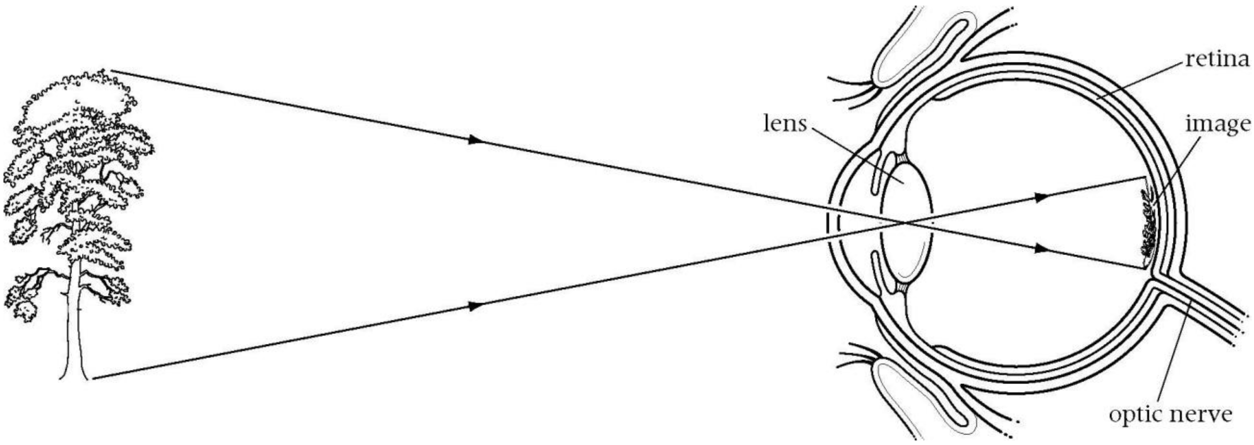
9P - 3b How Pinhole Cameras and Eyes work

1. Label the following pinhole camera using some of the statements below.



Statement

- small hole
- upside down image
- Light from one part of the flame can only reach one place on the screen.
- light ray from the bottom of the candle flame
- light ray from the top of the candle flame



2 Why is the image upside down?

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3 Why does a small hole give a sharp but dim image?

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4 Give two ways in which a pinhole camera is similar to the eye.

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5 Where in the eye is the image formed?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

6 Which part of the eye sends messages to the brain?

……………………………………………………………………………………………………

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7 Why do we see an image the right way up?

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……………………………………………………………………………………………………

8 What does the lens do?

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Extension:

9 How does the lens change in our eye to allow us to see things that are close or far away?

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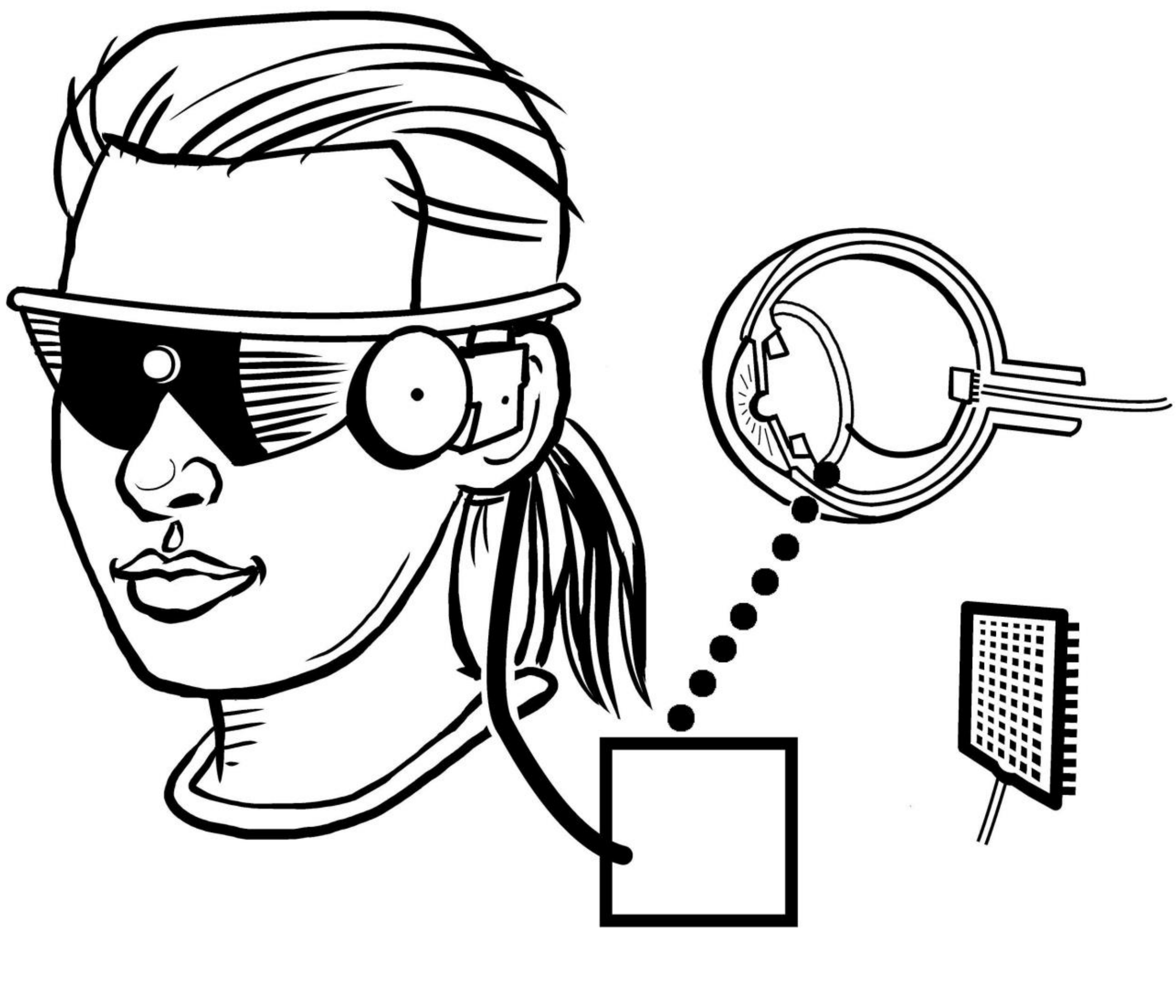
9P - 3c I Spy with my Bionic Eye

After exploring what we mean by light and how light rays behave you will find out how eyes and cameras work. You will then look at how science is improving the sight of people with poor vision using bionic implants.

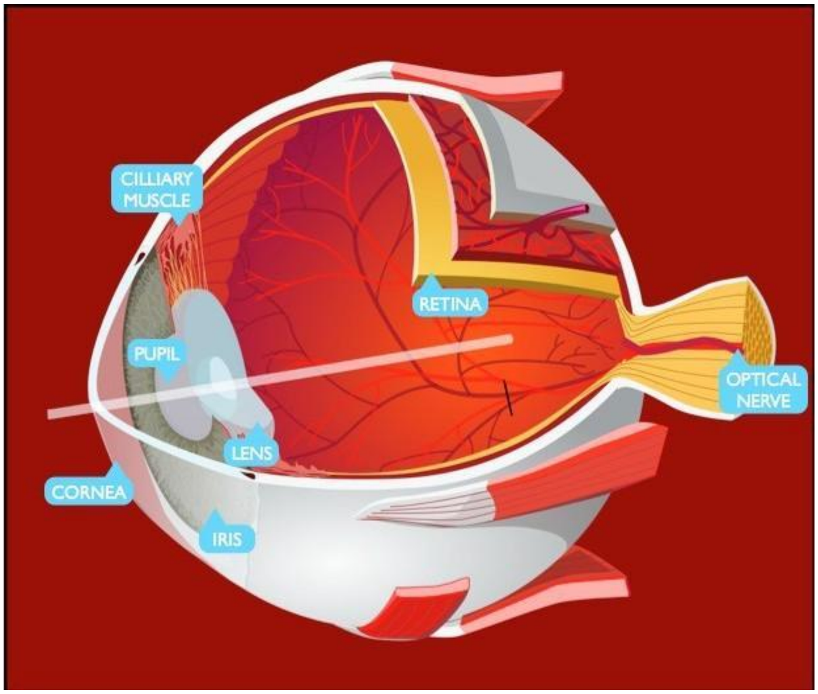


You will produce a leaflet or model or ICT presentation of a bionic eye implant system that improves vision for those with severe eyesight problems.

In your presentation, try and include some of the following:

- Describe what light is and some of its key properties.
- Explain how lenses work.
- Detail how the human eye functions, allowing us to 'see' objects.
- Detail how cameras work.
- Compare eyes and cameras, highlighting similarities between them.
- Explain how bionic eye implants function and lead to improvement in human vision.

9P - 3d Your eye as a camera



1. The **Cornea** and the **lens**, which is behind the iris, they are the eye's focusing elements. The cornea takes widely diverging rays of light and bends them through the pupil, the round opening in the central portion of the coloured iris.

2. The **Iris** adjusts the size of the **pupil** which acts like the aperture of a camera. The iris is a muscle which, when contracted, covers all but a small central portion of the lens, allows adjustable control of the quantity of light entering the eye so that the eye can work well in a wide range of viewing conditions, from dim to very bright light.

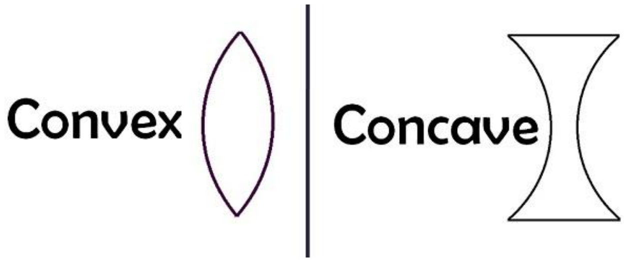
3. The **Retina** is the sensory layer that lines the very back of our eyes. It acts very much like the imaging sensor in a digital camera. The retina has numerous photoreceptor nerve cells that help change the light rays into electrical impulses and send them through the optic nerve to the brain where an image (of what we see) is finally received and perceived.

9P 4a - Lenses

Introduction

- Lenses are shaped pieces of glass which cause the rays of light passing through to change direction.

- There are two main types of lenses:



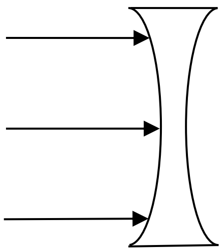
Experiment - Convex and Concave Lenses

Aim:
To investigate how rays of light travel through convex and concave lenses.

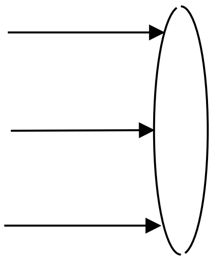
Prediction:

On the diagrams below, sketch what you think will happen as each of the incident rays pass through convex and concave lenses. Remember to use a ruler.

Hint: Think about what you know about refraction



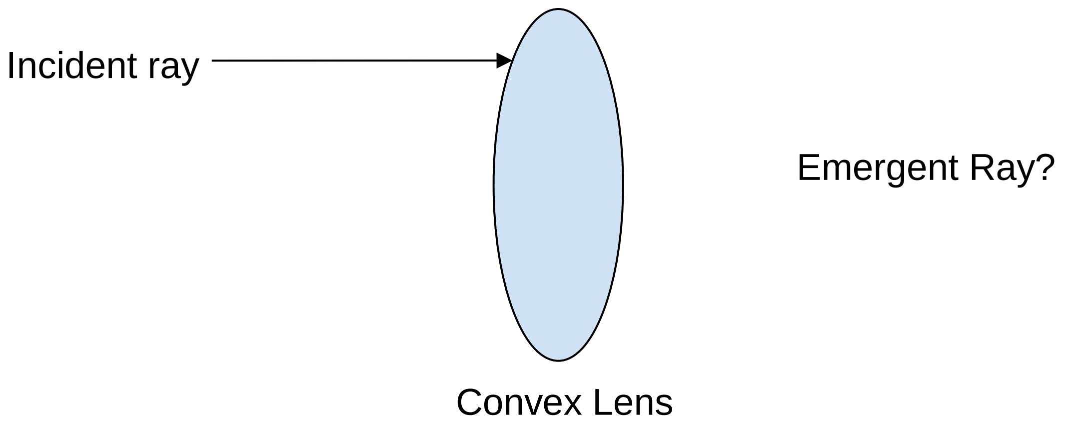
Concave Lens



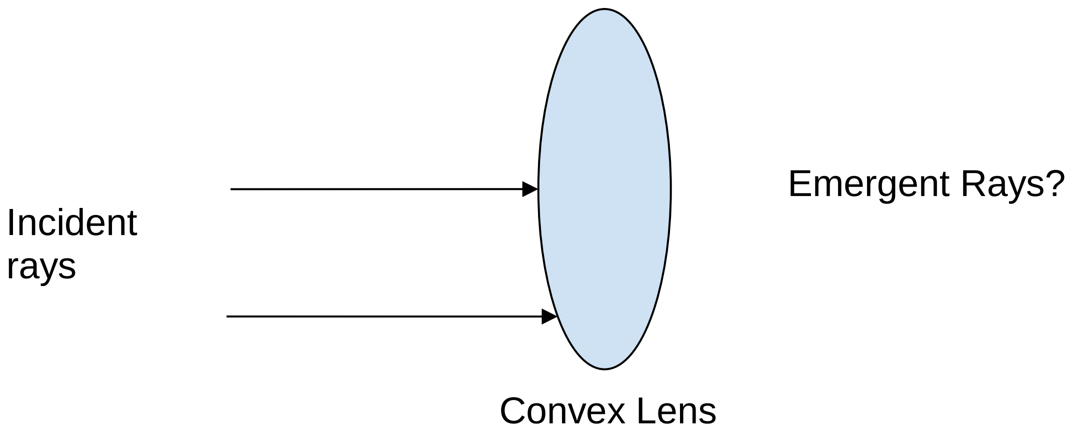
Convex Lens

Method:

1. Get a convex lens shaped block and draw around it on paper (on the next page)
2. Add a line as shown below to indicate the incident ray. Note that it is positioned near the top of the lens.



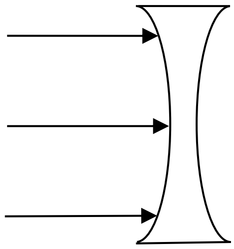
3. Alight your ray box so that the ray of light is perfectly aligned with the incident ray line.
4. Sketch the path of the emergent ray
5. Repeat steps 2 - 4 for light entering at the middle of the lens and at the bottom as shown in the diagram below.



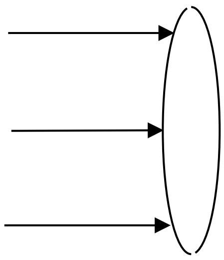
6. Repeat steps 1-5 for a concave shaped glass block.

<u>Conclusion:</u>

Complete the diagrams below by showing the path of the rays as they pass through and emerge from the concave and convex lenses.



Concave Lens



Convex Lens

Complete the conclusion statements below:

- A ray of light can change direction as it passes through a lens. This is caused by _____________. This is when a wave will change speed and sometimes direction as it goes from one medium into another.
- A convex lens is also known as a ____________lens. The rays meet at a point called the ______________.
- A concave lens is also known as a ____________ lens.

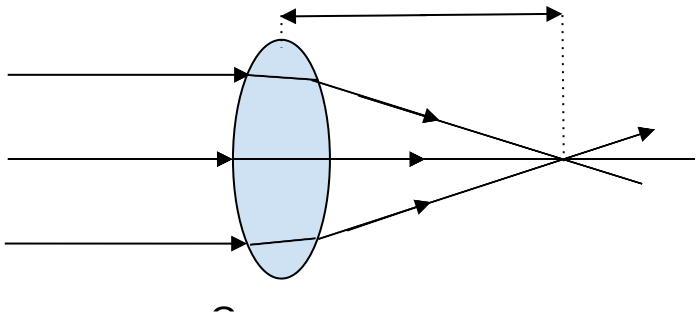
converging	diverging	focus	refraction

Extension:

Try different thicknesses of glass blocks.

9P 4b Investigating Focal Length

Experiment: Investigating the Focal Length of a Convex Lens:



Aim:
Your aim is to find the focal length of different convex lenses.

Method:
Your teacher will demonstrate how to measure the focal length of a convex lens.

There is also a video on ISLE.

Complete a step-by-step description of the method in the space below:

1.
2.
3.
4.
5.
6.

Results:

Lens (Colour Code)	Focal Length (cm)	Power (D) = 1/f

Observations:

What do you notice about the orientation of the image??
Can you explain it?

Extension Activities:

1. Calculate the power of each lens above by using the the equation:

   power = 1 / focal length

   power is measured in dioptres (D)
   focal length must be converted into metres (m) for the equation to work.

2. Draw a line graph of power v focal length.

3. Investigate how you would use a convex lens to magnify an image.

9P 4c Applications of Lenses and the Refracting Telescope

Applications of Lenses

Describe and explain some applications of lenses in the space below:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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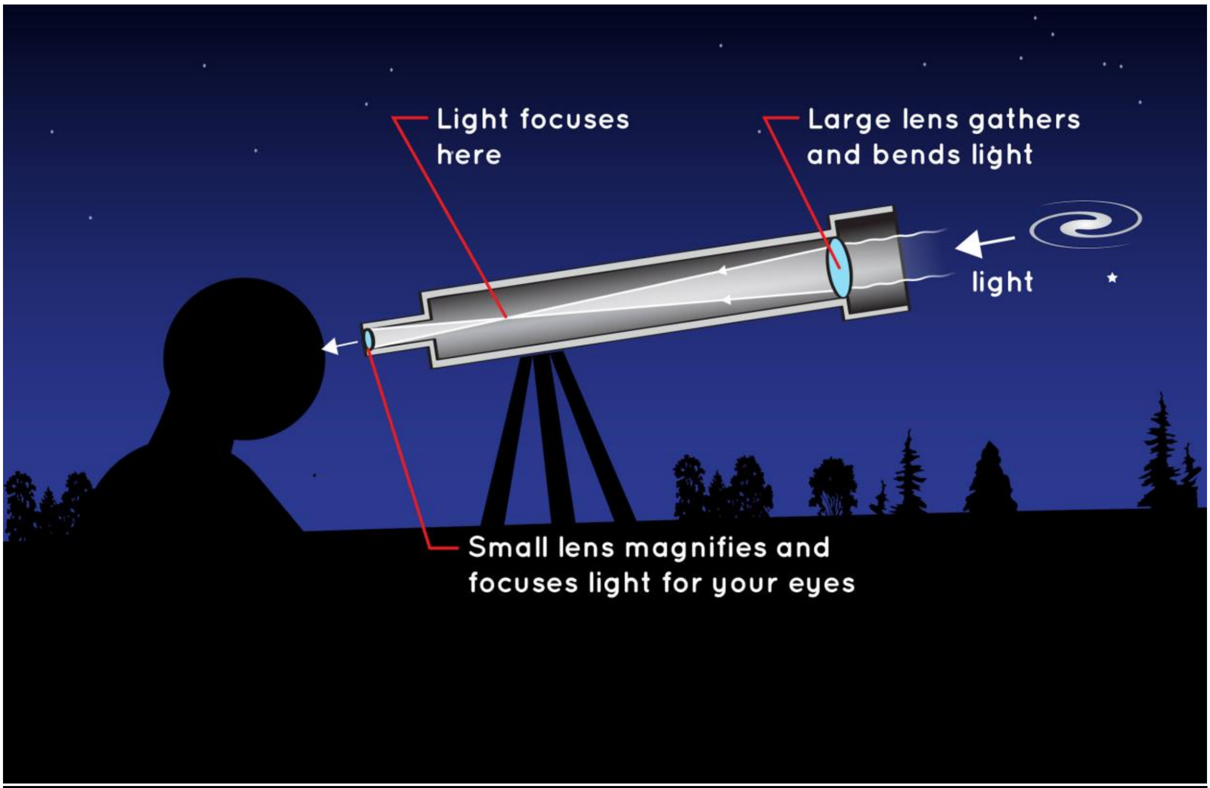
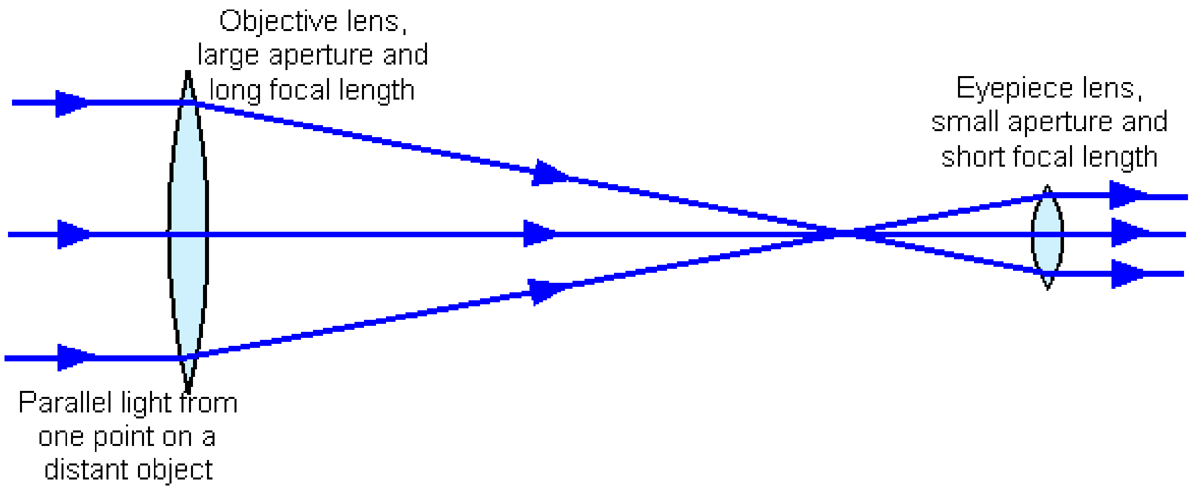
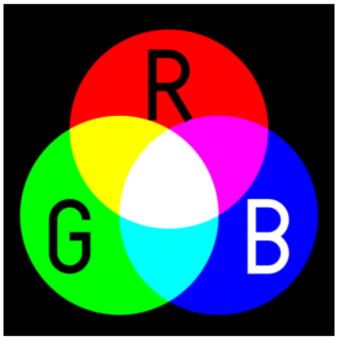
Refracting Telescopes:

A refracting telescope uses two lenses.





9P 5a - Colour Mixing



Class Experiment

Log onto: https://www.focuselearning.co.uk/

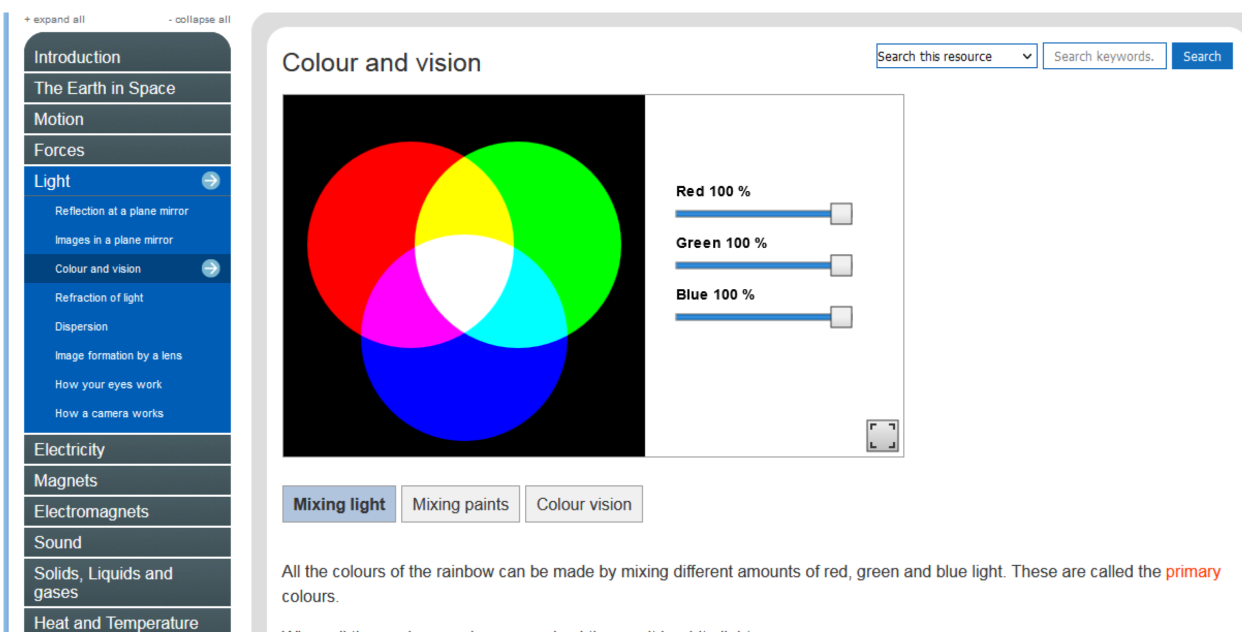
Username: **student@islandschool37651**

Password: **2y5wzdqhx**

Click on button named “ Essential Physics KS3”

Click on the Light section then Color and on the left-hand side panel

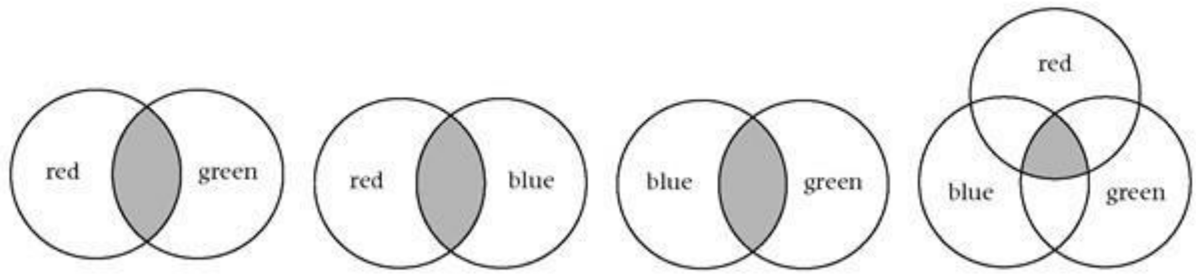
Start the experiment (only mix the light. **Do not mix the paint**)



Full link: https://www.focuselearning.co.uk/programmes/?frompack=&programme=essential-science-2018&page=light/light-colour&hl=colour%20mixing

1 Write down the colour which is made when these lights overlap. Some colours are listed below to help you.

pink cyan magenta orange white yellow violet



_________________ _________________ _________________ _________________

2 All the different colours that we can see in a rainbow are called

the S___________ of Visible Colours.

Three of these colours in the visible spectrum are p________ colours.

The primary colours are ___________ , _____________ and ____________ .

Primary colours are made from a single colour and not a combination of colours.

Two primary colours mixed together can make other colours

which are called s_____________ colours.

Red secondary spectrum Green primary Blue

Further Questions

In white light coloured objects reflect the light of their colour. The rest is absorbed.

Black objects absorb all colours. White objects reflect all colours.

If you have a red coat on, it appears red because only red light is reflected.

1. Which colours are absorbed by the red coat?

   …………………………………………………………………………………………

2. Which colours are reflected from:

a. a greenT-shirt **b.** black trousers **c.** a white shirt **d.** a blue jumper.

……………….. ……………….. ……………… ……………..

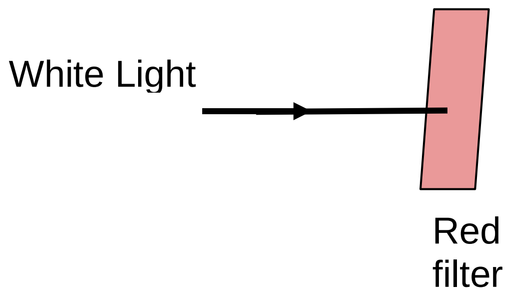
3. Fill in the colours:

Colour of object in white light	**Colour of object in this coloured light**			
	White light	**Red light**	**Blue light**	**Green light**
white				
red				
blue				
green				

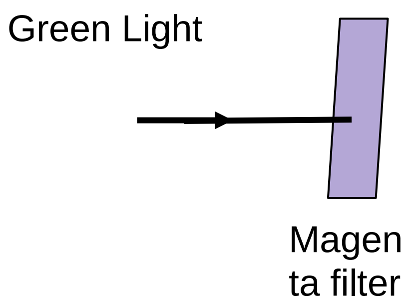
Extension Questions

4. You can change the colour of light by using filters. Filters only allow light of the colour of the filter through and absorb all the other colours. Explain what light will get through:

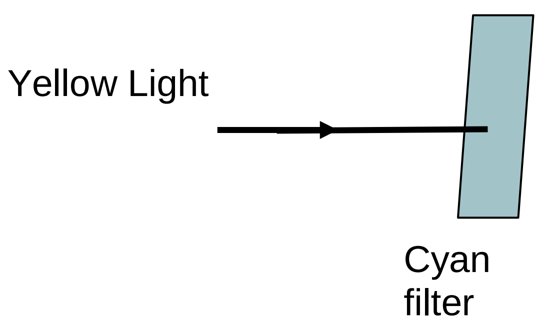
   a. White light hitting a red filter.



   b. Green light hitting a magenta filter



   c. Yellow light hitting a cyan filter



5. Which colours are reflected and absorbed by a yellow hat?

   ………………………………………………………………………………………………

6. Which colours are reflected and absorbed by magenta trousers?

   ………………………………………………………………………………………………

7. Coloured Objects in different lights.

Colour of object in white light	**Colour of object in this coloured light**			
	Blue light	**Red light**	**Magenta light**	**Yellow light**
yellow				
magenta				
cyan				
green				

9P - 5b Investigating Polarizers

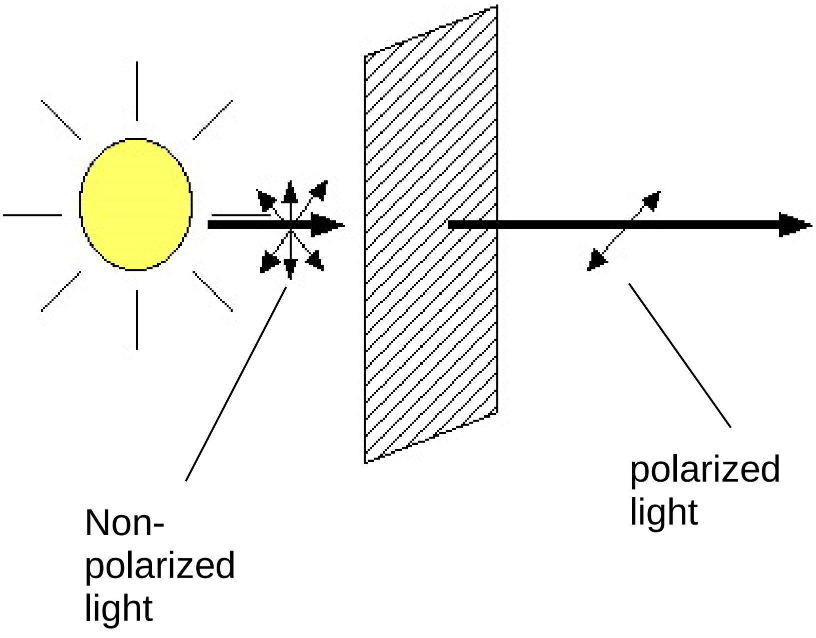
What are polarizers used for?

A polarizer may look just like a grey filter. However polarizers are key parts of Liquid Crystal Displays (LCDs).

Try looking at a:

- laptop screen
- calculator screen
- Smart-phone screen
- Smart-watch display

What is polarization?



Light from the sun or from a lamp is **non-polarized,** which means that the light wave vibrates in all directions.

After going through a polarizer the light is polarized meaning that the wave only vibrates in one direction. This direction of the polarization of the light is the same direction as the polarizer.

Can we find any polarizers or polarized light around us now?

Video on ISLE - Lesson 5 - Polarizers all around.

https://isle.island.edu.hk/course/view.php?id=1599

Your teacher might show you what a polarizer does to the light from the LCD Projector.

What happens?

The polarizer at different angles will allow different ………….. through.

In one direction the light was ………… and 90o later

the light was …………………..

Magenta is a combination of ……………… and ……………………

So since we have **green** and **magenta** light that means that all

three primary colours are there and we see …………………. Light.

Take in a Movie

Can you think of somewhere you might be sitting and wearing polarizing glasses?

> In a cinema the two polarizing lenses absorb different parts of the light from the screen and let different images through to the eyes. The brain puts these two images together and this creates the ……… effect.

Video on youtube: Removing Glare from a water surface

https://www.youtube.com/watch?v=ChQgV7DlkQo

Polarization in Nature

Light reflected from a water surface is naturally polarized. So using a polarizing filter helps cut out the 'glare'. Glare is unwanted light, just like noise is unwanted sound.

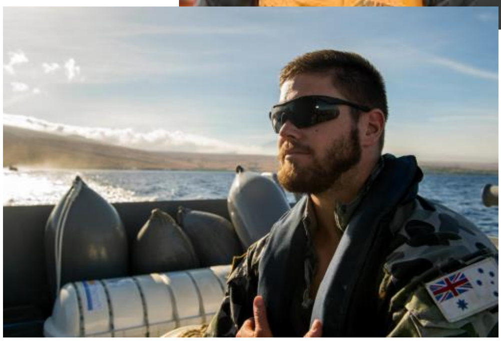
So polarizing filters are very useful in photography.

You can cut out the glare off the water and this helps see the light coming from the water.

'Eye Eye Sailor'

Why would a sailor wear polarizing sunglasses?

-
-
-
-



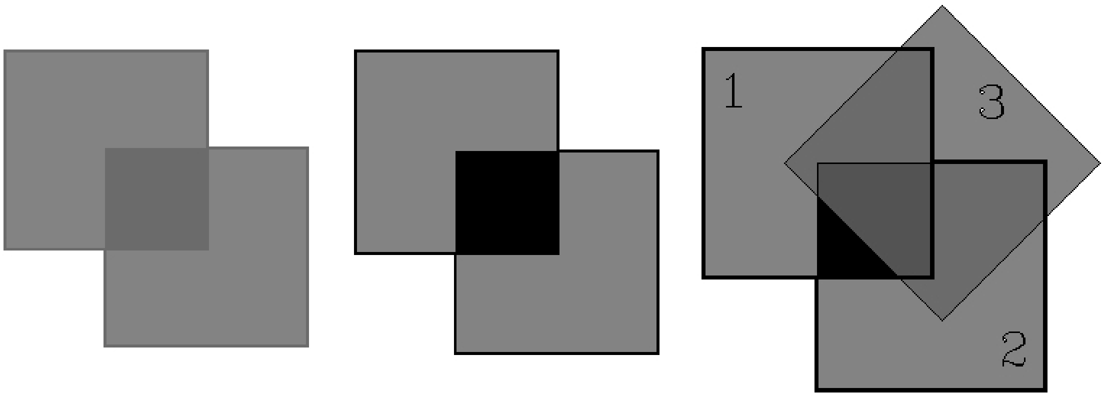
Summary

Polarizers can be used to absorb or transmit different light (more detail in the extension at the end), depending on the arrangement which we call the polarizarion of the light.

Investigating Crossed Polarisers

Download a light meter app onto your phone, or use a school light meter. Choose one that reads a brightness such as Lux and not an F number which is for photography.

What happens when you ‘cross’ two polarizers?



Parallel axes. Crossed axes. Polarizer (3) between two crossed polarizers (1) and (2).

- A Polarizer orientates the light into one direction (this is polarized light).
- A second polarizer in the same direction (parallel) will let the light through
- A second ploraser 90^{o} (crossed) will cut out all the light.

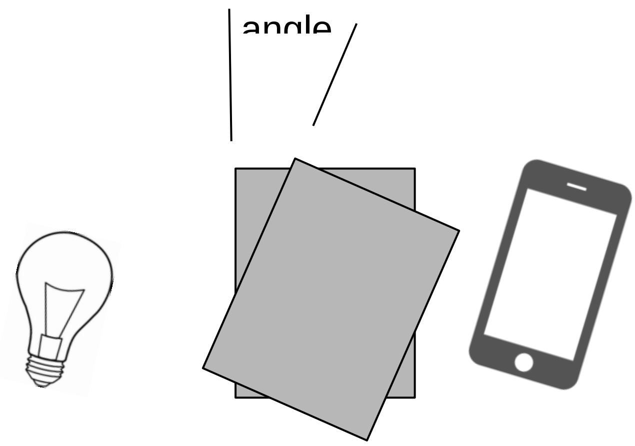
Research Question

How does the angle between two Polarizers affect the intensity of the light that passes through.

Apparatus

- Desk Light
- 2 polarizing filters
- Protractor
- Light meter (can be an app

  on your mobile phone)



Method

1. Arrange a light source and two parallel polarising filters so that maximum light reaches your light meter.
2. Measure the light intensity (brightness) at angles of 10^o , 20^o , 30^o , 40^o , 50^o , 60^o 70^o , 80^o and 90^o between the 2 polarizers.
3. Repeat and calculate an average.
4. Draw a graph of your results.

Results

(Video on ISLE has some results you can use - Lesson 5)
https://isle.island.edu.hk/course/view.php?id=1599

Angle between polarizers (degrees)	Brightness of light meter. Repeat 1. (lux)	Brightness of light meter. Repeat 2. (lux)	Average brightness of light. (lux)
10			
20			
30			
40			
50			
60			
70			
80			
90			

Graph

Conclusion

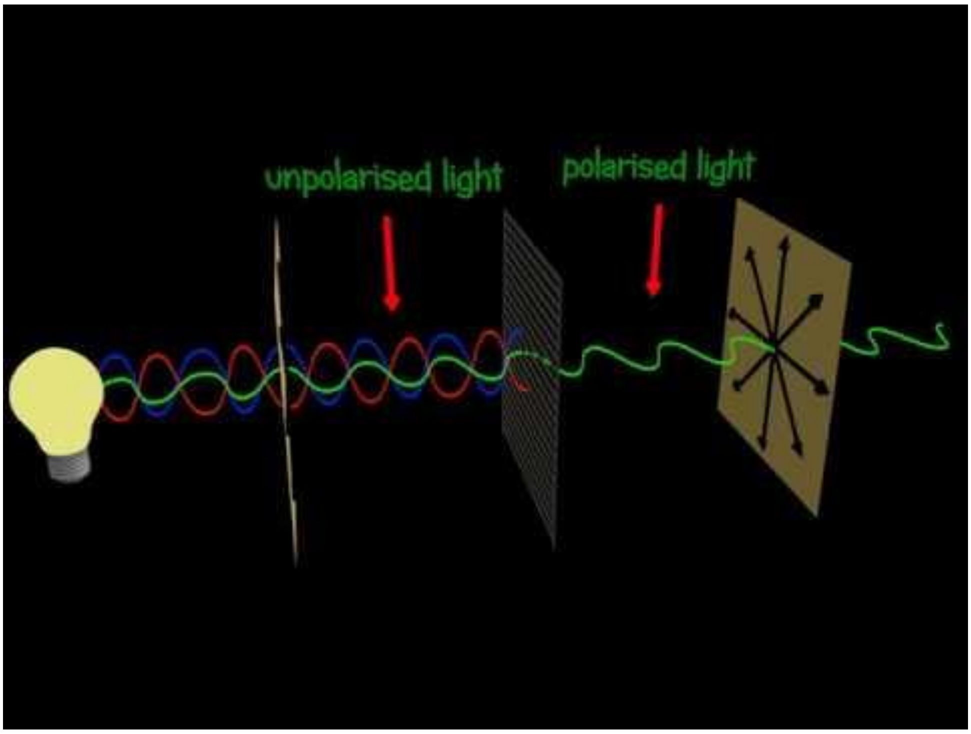
The greater the angle between the polarizers the ***greater / lower*** the intensity of light that passes through.

Two parallel polarizers ***transmit / absorb*** light

Two ‘crossed’ polarizers (perpendicular) ***transmit / absorb*** light.

Extension

How do polarizers work? Here is a video to explain how.

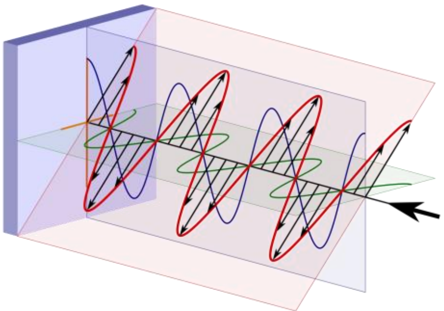


(https://www.youtube.com/watch?v=11w32FwMvbl)

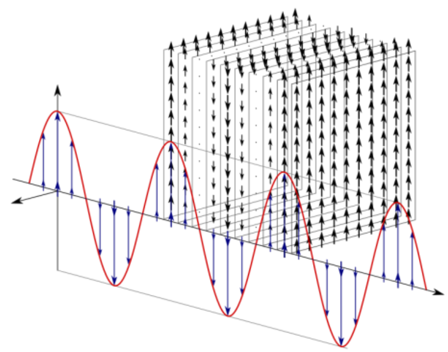
Non-polarized Light, such as sunlight vibrates in all possible directions, but polarized light vibrates in one plane only.

9P 5c - More Polarization

1. When a light wave vibrates in all directions, the light is _____-___________.



2. When a light wave vibrates in a single plane, it is _______________.



3. A Polaroid or Polarizing filter polarizes light by only

allowing light in one ………..………...to pass and absorbing light vibrating in all other directions.

A polarizing filter will: (delete the incorrect answer)

a. twist all the wave vibrations so that they line up in a single plane

b. block part of the vibrations while letting through only those in a specific plane

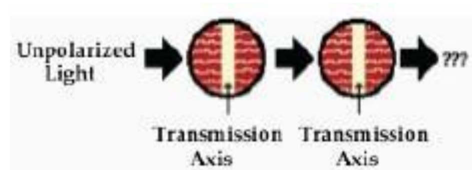
4. Filters allow light to pass through. Polaroid filters are very selective about the orientation of the light vibrations that are allowed through. The light that passes through a Polaroid filter is vibrating in a direction that is ____________ to the orientation of the polarizing filter.

5. Will light pass through this pair of polarizing filters?

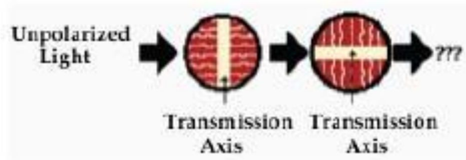
…………………………………………………………..

…………………………………………………………..

…………………………………………………………..



6. Will light pass through this pair of polarizing filters?



…………………………………………………………..

…………………………………………………………..

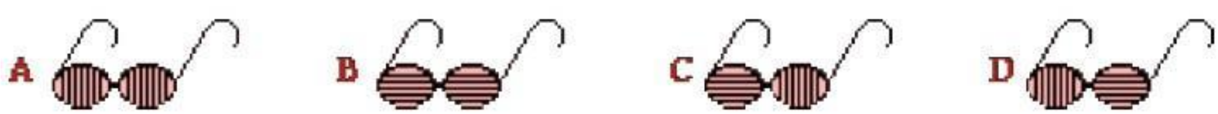
…………………………………………………………..

7. Passing light through a Polaroid filter is not the only way that unpolarized light can be polarized. Light is also polarized when it reflects off non-metallic surfaces. When light reflects off nonmetallic surfaces such as glass, water, or a road surface, the light is partly polarized. The reflected light consists of waves that are vibrating mostly _____ to the reflecting surface.

a. Parallel

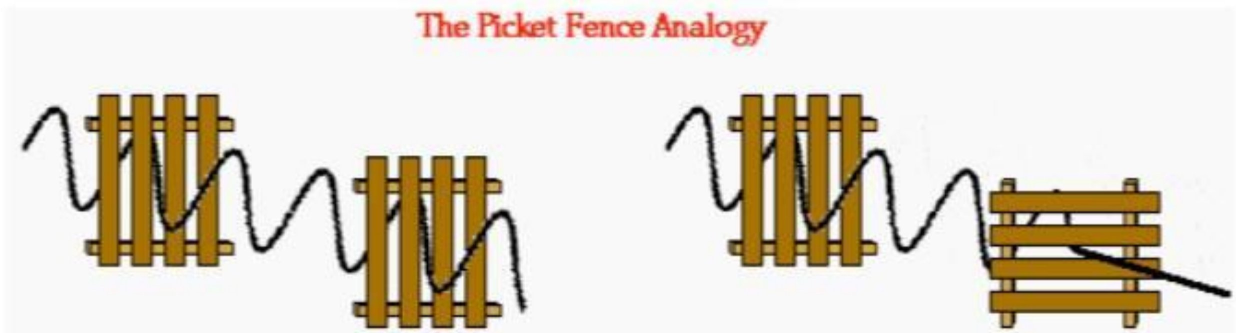
b. Perpendicular

8. Mr Winde is driving down the road on a sunny day. Reflection of light off the road surface results in a large amount of glare. The glare is polarized in the horizontal plane. Annoyed by the glare, Mr Windle pulls out his Polaroid sunglasses. How must the axes of polarization be oriented in order to block the glare? (Note: the lines on the filters below represent the axis of polarization.)



Answer: ……………..

9. The picket fence analogy is often used to explain Polarization. Use the picket fence analogy to explain your answers to questions #5 and #6. Make reference to the diagrams below in your explanations.



Q5. (left hand diagram)	Q6. (right hand diagram)
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
………………………………………………	………………………………………………
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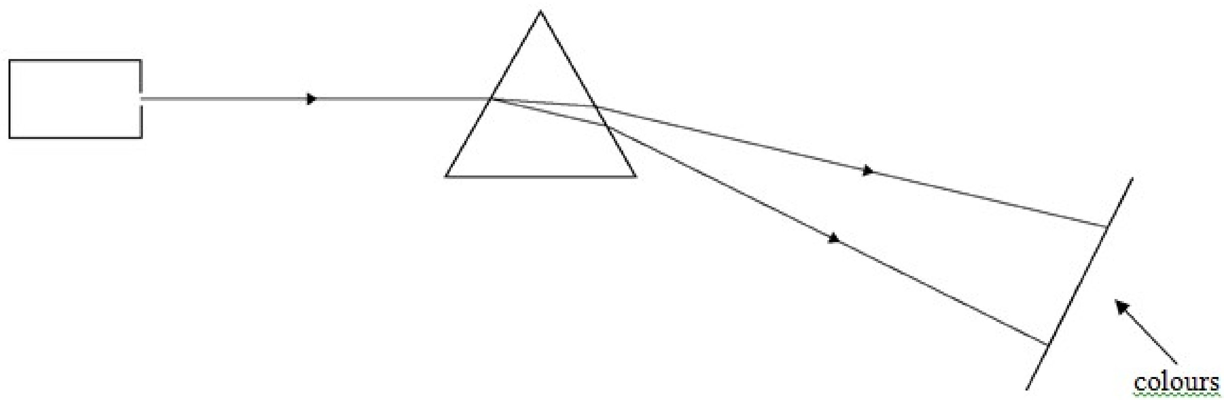
9P 6a Splitting light using Refraction

How does a prism split light into different colours?



Label the **ray box**, **prism** and **screen** on the diagram above..

Method:

1 Set up the apparatus as shown in the diagram above.

2 Shine a ray of light through the prism until you see a spectrum of colours produced on the screen or the paper.

3 Label on the diagram above, what colours you can see and then fill in the table of results.

Results:

<table>
<tr><th>Colour</th><td rowspan="8">Refracted Least
↓
Refracted Most</td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
</table>

<u>Conclusion:</u>

1 Which colour was refracted the least?

2 Which colour was refracted the most?

3 What are the seven colours that white light can be split into?

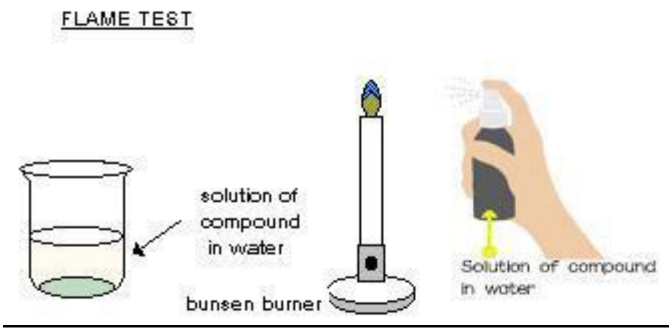
4 If you mix these 7 colours of light, what colour does it give?

Extension Activities:

1. Research and find out why refraction is able to split white light into seven colours.
2. Which of the colours has the longest wavelength?
3. Which of the colours has the shortest wavelength?
4. How is a rainbow formed and why is it that shape?
5. Explain with a diagram, how a rainbow forms.

9P 6b Flame Testing and Emission Spectra

Flame Testing Practical



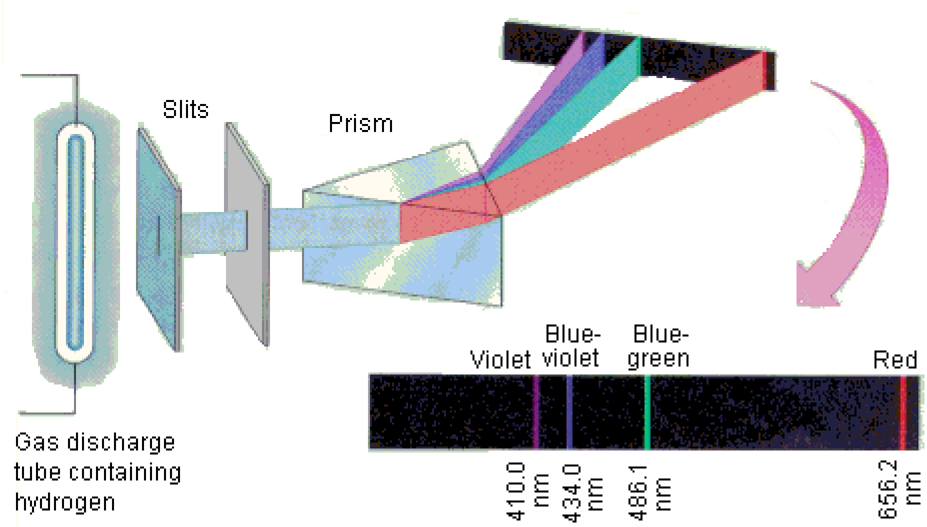
1. For each compound, identify the metal element present.
2. Lightly spray each solution into the roaring blue bunsen burner flame and observe the colour of the flame.

Compound	Metal Element	Colour
X		

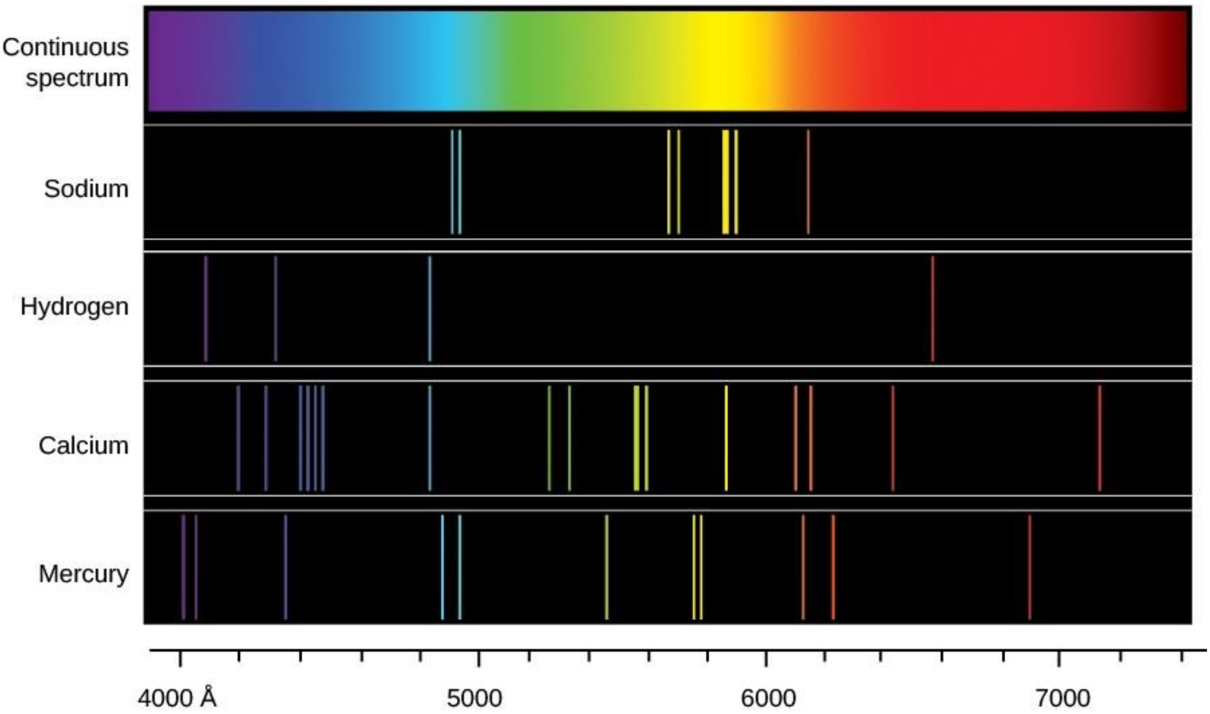
For Mystery compound X, conduct a flame test and identify the metal element contained in it.

Emission Spectra

- The colours you observed above are actually a combination of a specific set of colours mixed together.
- The set of colours that are produced can be separated (using a prism or diffraction grating) to form a line emission spectra.
- The line emission spectra is unique to that particular element. It can therefore be used to identify elements.

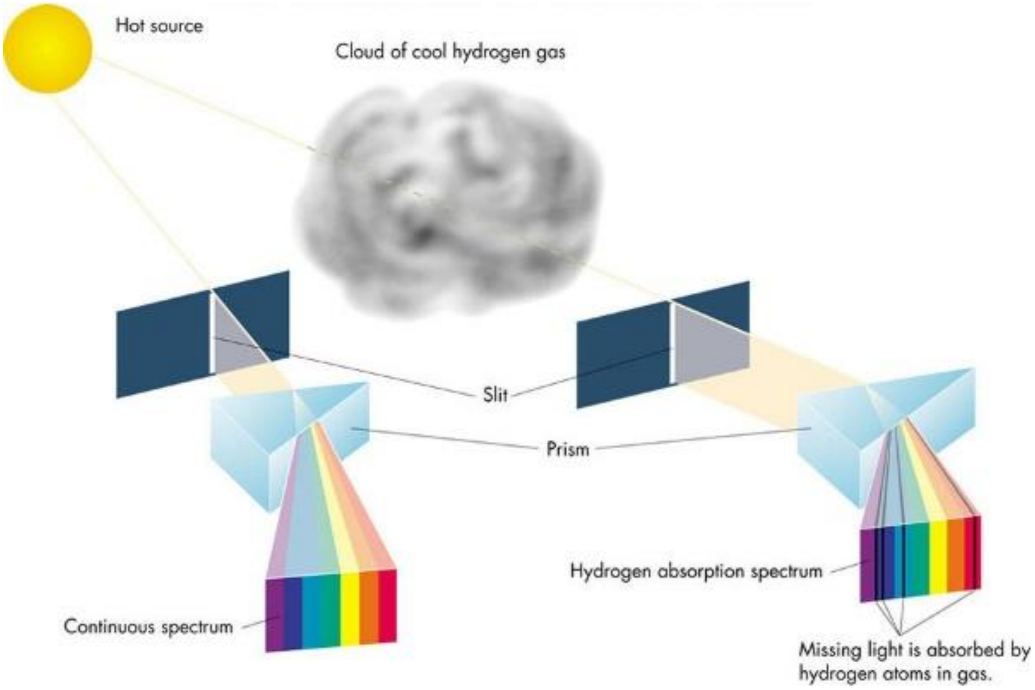


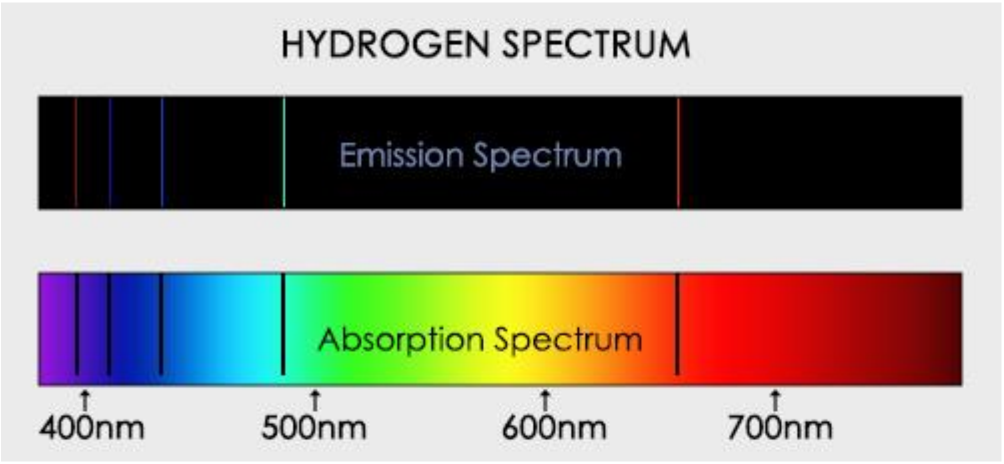
Your teacher may show you a demonstration using gas discharge tubes to form spectra for different elements.



9P 6c Stellar Spectra

The interior of a **star** produces a continuous spectrum of light, like a rainbow. Cooler gases in the outer layers of the star absorb certain wavelengths of light, causing dark lines to appear in the spectrum. The resulting **absorption spectrum** can tell astronomers a great deal about the star.





- The lines of an emission spectra for a particular element will match up with the missing lines that are observed in an absorption spectra.
- The emission lines and absorptions lines are unique to that particular element.
- These spectra allow you to identify the element(s) present in a star. The spectra are a bit like the element's unique 'fingerprint'.

How are stars classified?

Introduction: Late in the 19^{th} century, Harvard astronomer Edward Pickering wanted to sort and catalog the thousands of star spectra that had been collected by the Harvard Observatory. He hired several women to do the work, paying them 25 cents a day. The most prominent of these women was Annie Jump Cannon, who devised a classification system still used today.

Harvard Classification Scheme			
Class	**Color**	**Prominent spectral lines**	**Surface Temp. (K)**
O	Blue	Ionized helium, hydrogen	> 25,000
B	Blue-white	Neutral helium, hydrogen	11,000 – 25,000
A	White	Hydrogen, ionized sodium, ionized calcium	7,500 – 11,000
F	White	Hydrogen, ionized sodium and calcium; neutral sodium and calcium	6,000 – 7,500
G	Yellow	Neutral sodium and calcium, ionized calcium, ionized iron, ionized magnesium	5,000 – 6,000
K	Orange	Neutral calcium, neutral iron, neutral magnesium	3,500 – 5,000
M	Red	Neutral iron, neutral magnesium, and neutral titanium oxide (not shown)	< 3,500

Classification Activity

Use the Gizmo to find the elements that are present in the spectra of stars 1 through 4. Remember to check both the **Neutral spectra** and the **Ionic spectra**. Then use the table above to classify each star and describe its surface temperature. (Note: A star spectrum may not display lines of all of the elements typical of its spectral class.)

Star	Color	Elements in spectrum	Class	Surface Temperature (K)
1				
2				
3				
4				

Extension: What else can we learn from stellar spectra?

1. Observe: Observe the spectra of stars 5 – 10. Identify the elements in each spectrum, and try to classify each star. If you notice unusual features in these spectra, describe them.

Star	Color	Elements in spectrum	Class	Unusual features
5				
6				
7				
8				
9				
10				

Match: Write the number of the star or object that matches each description. Then use this information to help you identify the elements and reclassify the stars in the table above.

____ High atmospheric pressures in a star cause spectral lines to be broadened, or “smeared out.” **Giant stars**, which have relatively low atmospheric pressures, are characterized by narrow spectral lines.

____ If a star is moving away from an observer, spectral lines are **redshifted**, or shifted toward the red end of the spectrum. An approaching star is **blueshifted**.

____ A star orbited by a large planet will move in a small circle. This will cause its spectrum to be slightly redshifted part of the time and blueshifted at other times.

____ **Binary stars** are pairs of stars that orbit one another. Their presence is indicated by two spectra that shift in opposite directions.

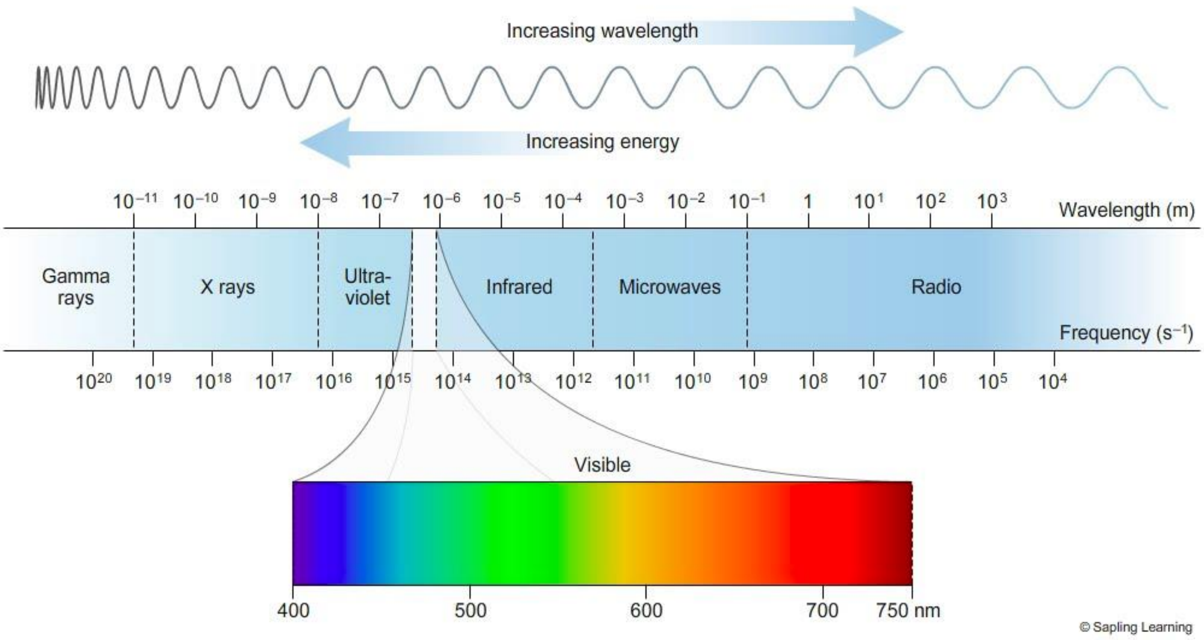
____ **Cepheid variable** stars change their brightness in a regular cycle. Gas pressure builds up, causing the stars to expand quickly. When the pressure is released, the star contracts, and the intensity of some spectral lines may decrease.

____ A **nebula** is an enormous cloud of gas and dust in which stars are born. Most nebulae produce an **emission spectrum**, which is characterized by bright lines of color against a dark background. The bright lines in an emission spectrum correspond to the dark lines in an absorption spectrum.

9P 6d EM Spectrum

EM Spectrum

Visible light is just a tiny part of a much bigger spectrum called the Electromagnetic or EM spectrum. Just like visible light, the EM spectrum is made of waves of different wavelengths and frequencies.



- The gamma ray end of the spectrum is the high frequency, low wavelength, high energy and high danger end of the spectrum.

- The radio wave end of the spectrum is the low frequency, high wavelength, low energy and least dangerous end of the spectrum.

- All parts of the EM Spectrum travel at the speed of light which is: **3×10^8m/s**

Extension / Homework Activity:

Pick a part of the EM Spectrum and research an application/use of this part.

9P 7a - Gravity and the Solar System

Deep Learning Outcomes

1. Gravity keeps the planets in orbit around the sun.
    a. The planets of the Solar System
    b. Characteristics of the planets
2. How does Orbital Speed change with distance from the Sun.
3. How does Orbital Period (year) change with distance from the sun.

Part 1 - Gravity

Gravity is one of the fundamental forces in the universe. We are inside the Earth's gravitational field.

What is a Field?

A field is a region (or space) in which an object experiences a **non-contact …………..**

A Gravitational Field is a region in which a **……………..** experiences a **non-contact ………..**

The Solar System

SOLAR SYSTEM VIDEO - 12mins
https://www.youtube.com/watch?v=Qd6nLM2QlWw

Research the 8 planets of the Solar System.
The **distance from the sun to earth** is called an **Astronomical Unit (AU)** and is a useful unit in astrophysics.

Name of planet	Rocky or Gas?	Distance from the Sun (AU)	Speed (km/s)	Year (days or years)	Interesting fact(s)
Mercury				88 days	
Earth		1.0			
(Pluto) (no longer a planet)	Rocky	39.5	4.7	248 years	It's moon is called Charon (the ferryman of Hades)

Model Solar System

Can you make a scale model of the solar system? Measure the masses of pieces of plasticine to the correct proportion, taking the Earth to be 1g. Do **only one** of each planet for the whole class.

Planet	**Mass of planets relative to the mass of the Earth**	**Mass of plasticine / grams**
Mercury	0.05	0.05
Venus	0.8	0.8
Earth	1	1
Mars	0.1	0.1
Jupiter	300	300
Saturn	100	100
Uranus	15	15
Neptune	17	17

Extension

[Scale Calculator]

If the model earth was placed 1m away from the sun how far from the sun would the other planets be?

Planet	**Distance from the Sun (AU)**	**Distance from the Sun in your model / m**
Mercury	0.4	0.4
Venus	0.7	0.7
Earth	1	1
Mars	1.5	1.5
Jupiter	5	5
Saturn	10	10
Uranus	19	19
Neptune	30	30

Can you put your planets in the correct relative spacing?

- You might just fit this into the corridor.
- Put each planet on a piece of paper so that you do not stand on them.

Extension - Planet Fall

1. Why was Pluto downgraded to a Dwarf Planet in 2006?

    -

2. Is there anything else unusual about Pluto's orbit?

3. How can you remember the order of the planets:

4. Why is Venus the hottest planet in the Solar System when Mercury is closer to the sun?

Part 2 - Orbital Speed

What happens to the speeds of the 8 planets as you go further from the sun?

Plot a graph to see the relationship. Put Distance from the sun on the x-axis and orbital speed on the y-axis.

Try using Google Sheets to produce your graph.

There is a video on ISLE of a demo of using Google Sheets.

Results Table

Name of planet	Distance from the Sun (AU)	Speed (km/s)
Mercury		
Earth	1.0	

Graph

Conclusion

Describe the trend. Use ideas like Gravitational Energy and Kinetic Energy to explain your conclusion.

Part 3 - Orbital Period

Orbital period is the time it takes for the planet to orbit the sun once. We also call this the year. For Earth, the year is 365 days.

How does the orbital period of the 8 planets change with the distance from the sun?

Plot a graph of Orbital Period (in earth years) on the y-axis against distance from the Sun (in AUs) on the x-axis.

Try using Google Sheets.

Results Table

Name of planet	Distance from the Sun (AU)	Year ('earth years')
Mercury		(88/365) = 0.24
		(225/365) = 0.62
Earth	1.0	1.0

Graph

Conclusion

Describe the trend and try to explain it. Use ideas like circumference and speed to explain your conclusion.

Questions

[Gravity and the Solar System | Science Quiz](https://quizizz.com/admin/quiz/5d631e5d655a24001e90bc28/gravity-and-the-solar-system)
https://quizizz.com/admin/quiz/5d631e5d655a24001e90bc28/gravity-and-the-solar-system

[Kahoot me up](https://create.kahoot.it/share/the-solar-system/2a07be85-8669-4fe6-8ade-7b34598b3c5d)
https://create.kahoot.it/share/the-solar-system/2a07be85-8669-4fe6-8ade-7b34598b3c5d

Extension Questions

1. Why does the Earth have seasons?

2. What is the Milky Way and what time of year is it the best time of year to see it?

3. How many potentially inhabitable exo-planets have been found?

4. Why is the Astronomical Unit a useful unit for astrophysics?

The Moon and its Phases

Moons

Most of the planets in our solar system have moons. The number of moons that these planets have (at the time of writing), range from 0 to 95 (with more being discovered every year!).

Try to answer these starter questions in 5 minutes…

1. Which planet has the most moons?

2. Which planets have no moons?

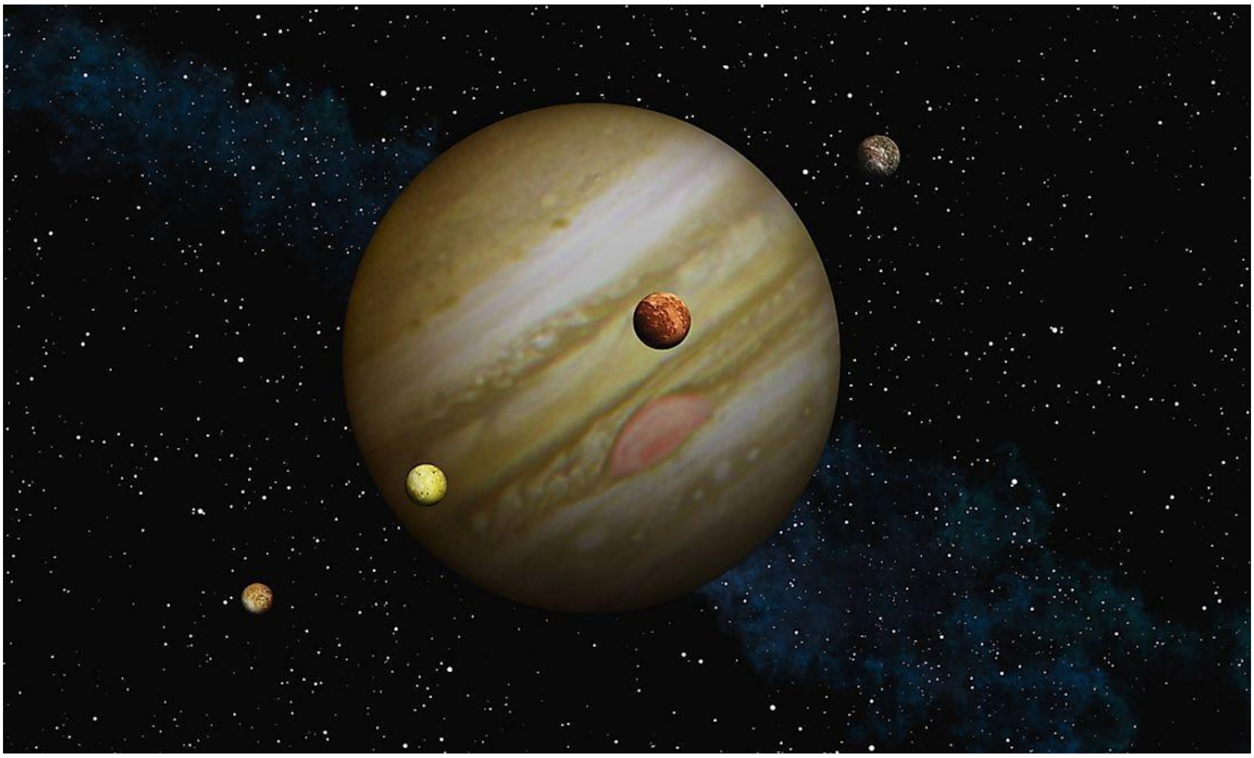
3. How are moons formed?

The Earth's moon is appropriately called 'the Moon' and is in orbit at a distance of 385,000 km from the Earth..

Do you know any other facts about the moon? Talk to your neighbor and discuss what each of you know about the Moon.

Make some notes here and report back if asked:

Further Research of Moon Facts

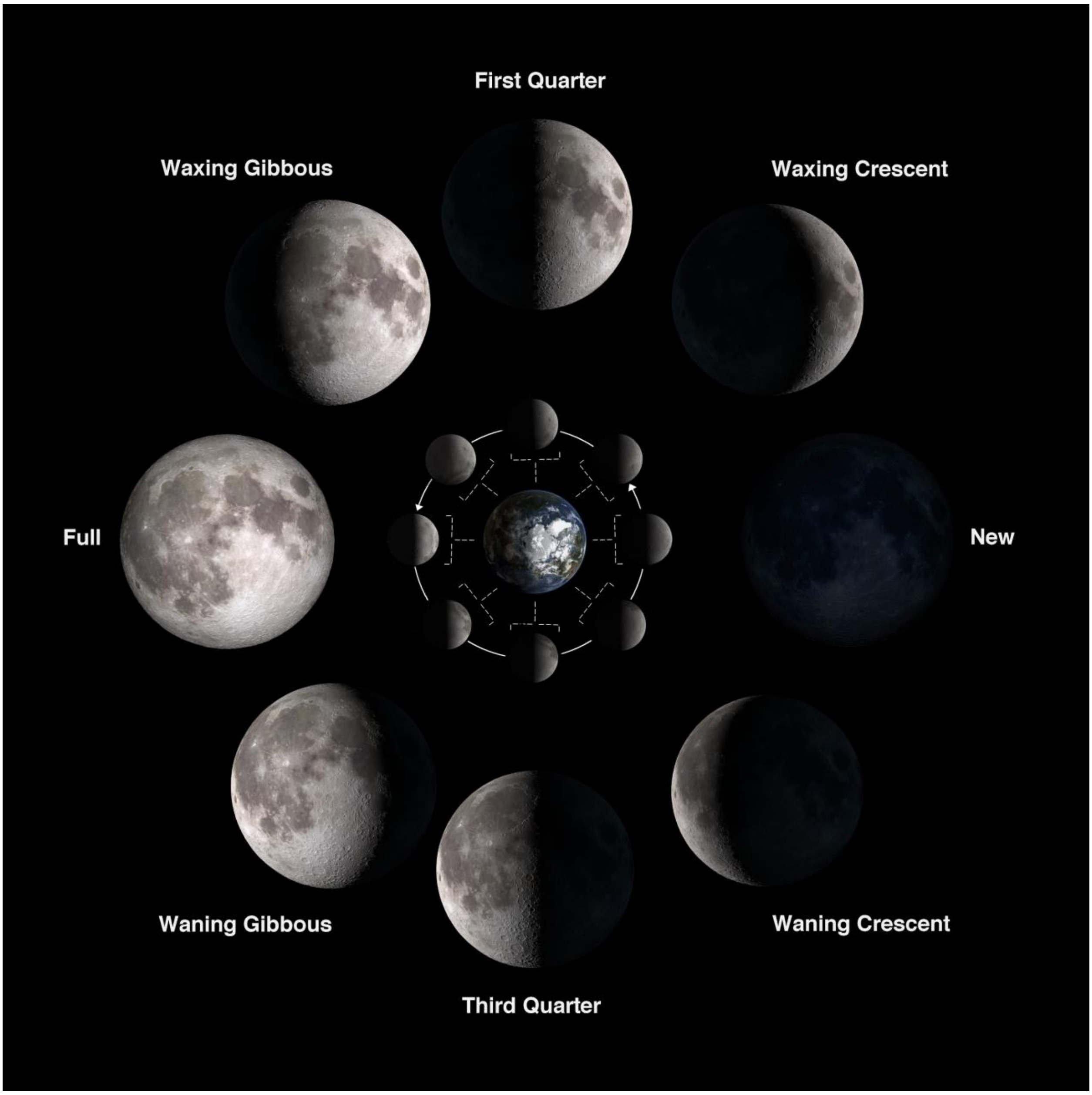


Which planet shown with some of its moons is this one?

Complete the table below (try to remember the order of the planets without looking):

Name of Planet	Number of Moons
Mercury	

Phases of the Moon



The Moon looks different at different times of the month and this is because of the relative positions of the Earth, Moon and Sun. Look at this image with a neighbour and see if you can discuss and understand what it is showing.

Log on to the Gizmo to learn more about this:

https://gizmos.explorelearning.com/

Find the Gizmo entitled “Phases of the Moon” and click on “launch Gizmo”

Click on the play button and watch how the light from the sun and the position of the Moon changes the way the Moon looks from an observer on Earth.

By doing this you can understand the phases of the Moon by observing the positions of the Moon, Earth and Sun. A view of the Moon from Earth is shown on the right as the Moon orbits Earth. Learn the names of Moon phases and in what order they occur. Click Play to watch the Moon go around, or click Pause and drag the Moon yourself.

After you have had a play try to complete the Exploration sheet. Your teacher may add this to your google classroom or you may be able to access this on the Gizmo site.

Practical Work

By using a lamp (the Sun) and a small white ball (the moon). Your head can be the Earth!. See if you and a partner can simulate the motion of the moon. Try to see if you can identify the 8 phases of the moon.

Watch this video Moon Phases Demonstration

This will give you an idea of how to carry out your practical work.

If you can try to take a photo of the moon (the small ball) in its eight phases. If time you can test yourself by drawing and labelling the eight phases of the moon below-you could use your photos to copy from if they are good images:

The many moons in our Solar System are all very different. Try to find a moon that has some unique qualities and do a little research.

Jot down some fun facts below and be ready to share

Unique Moon fun facts

9P 8a Galaxies and The Universe

Galaxies

Answer the following questions in full sentences:

1. What is a galaxy?

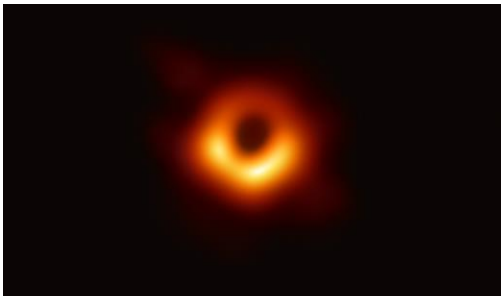
2. The sun is part of which galaxy?

3. What are the 3 main categories of galaxy?

4. What is the Universe?

FunFact:

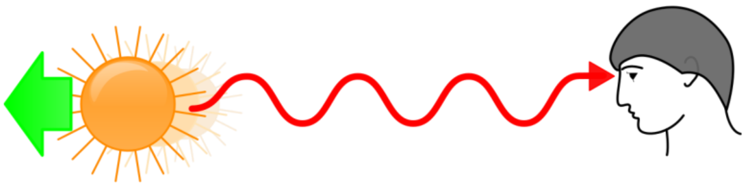
In recent years we have discovered that there is a supermassive black hole at the centre of almost all galaxies, including our own.

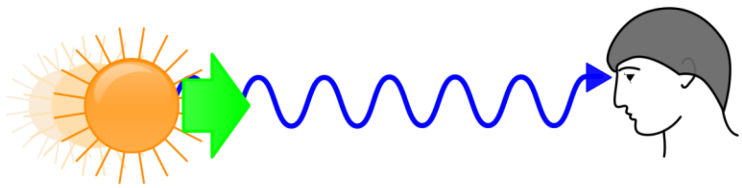


9P 8b Redshift

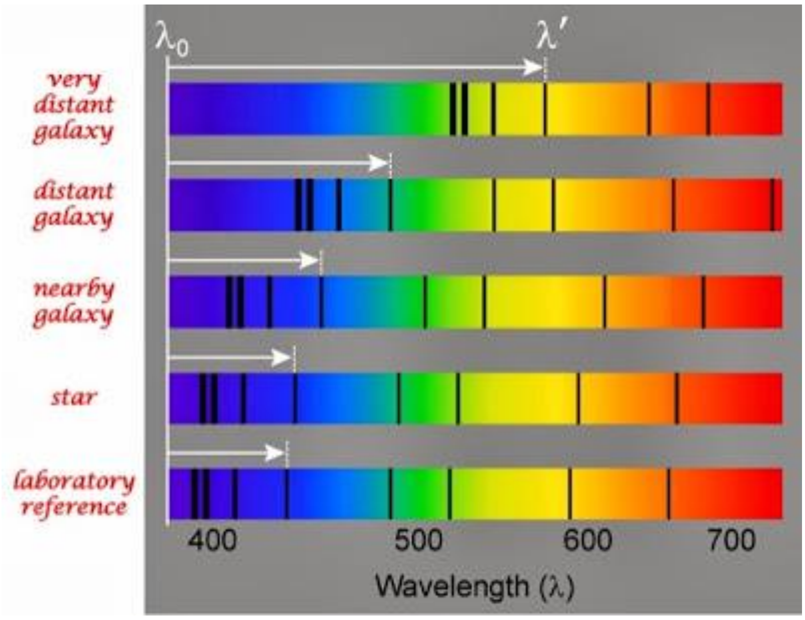
Redshift and The expanding Universe

When the source is moving away from you, each wave is emitted further away than the wave before. This means that the wavelength of the wave is now _______________ and since the speed is the same and speed = frequency x wavelength the observed frequency is therefore ________________, and moves towards the red part of the visible spectrum. This is called ______________.





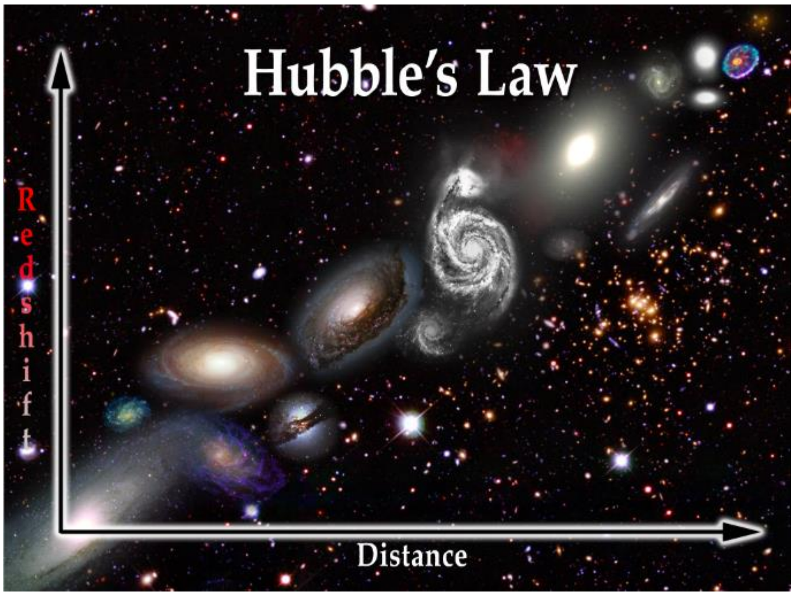
When we measure the light from other galaxies we see that the hydrogen lines have a Red-Shift!



9P 8c Hubble's Law

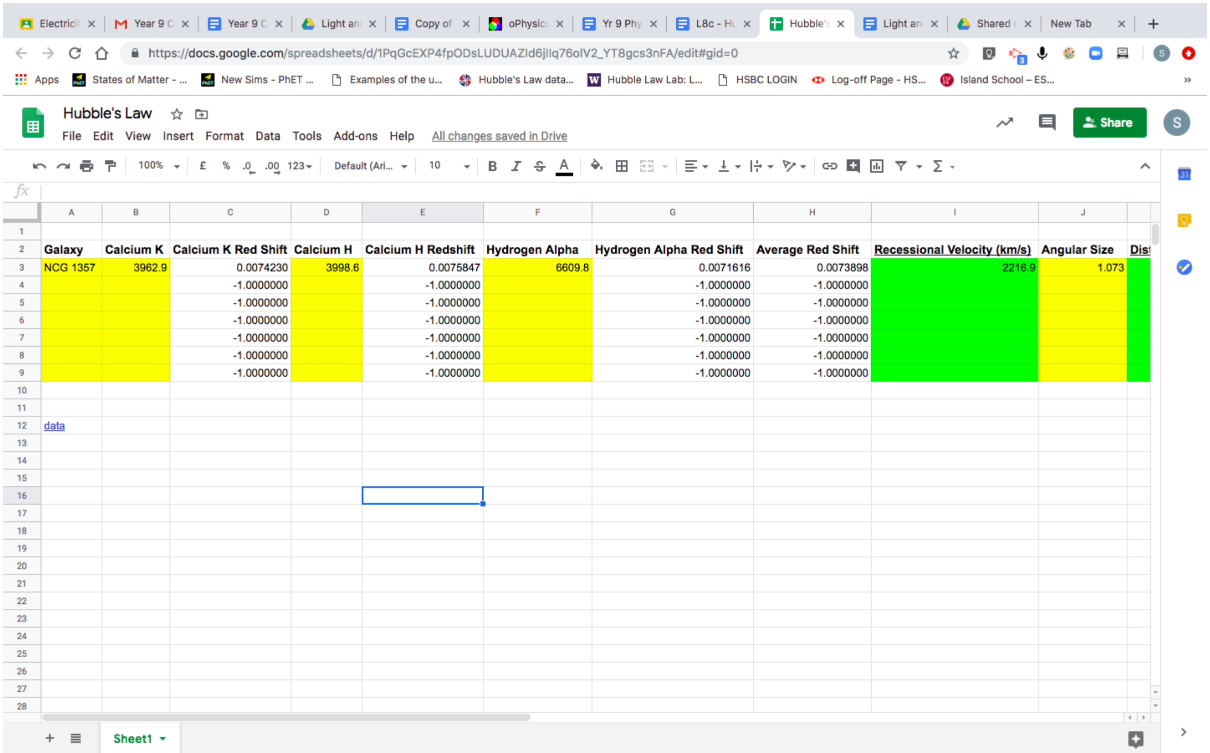
Aim:

In this investigation you will be using real scientific data to investigate the relationship between **recessional velocity of galaxies** and the **distance** they are away from us.



Instructions:

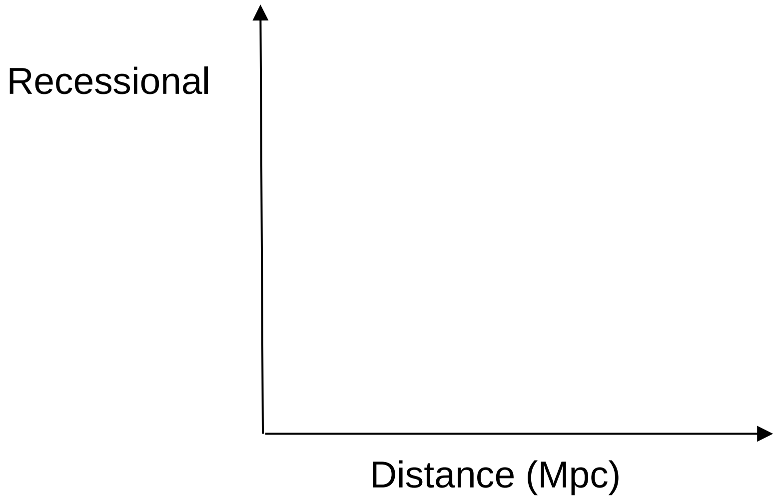
1. Access your Google Sheet entitled 'Hubble's Law'



2. Watch the screencast showing how to collect the data and record it in your own spreadsheet.
3. Here is the link to the data: [Hubble's Law Data].
4. Collect data for 7 galaxies.

Analysis:

Plot a line graph of recessional velocity v distance. There is another screencast about how to produce a line graph.



Conclusion:

What is the relationship between the recessional of galaxies and how far they are away from us?

____

____

____

Can you explain this relationship?

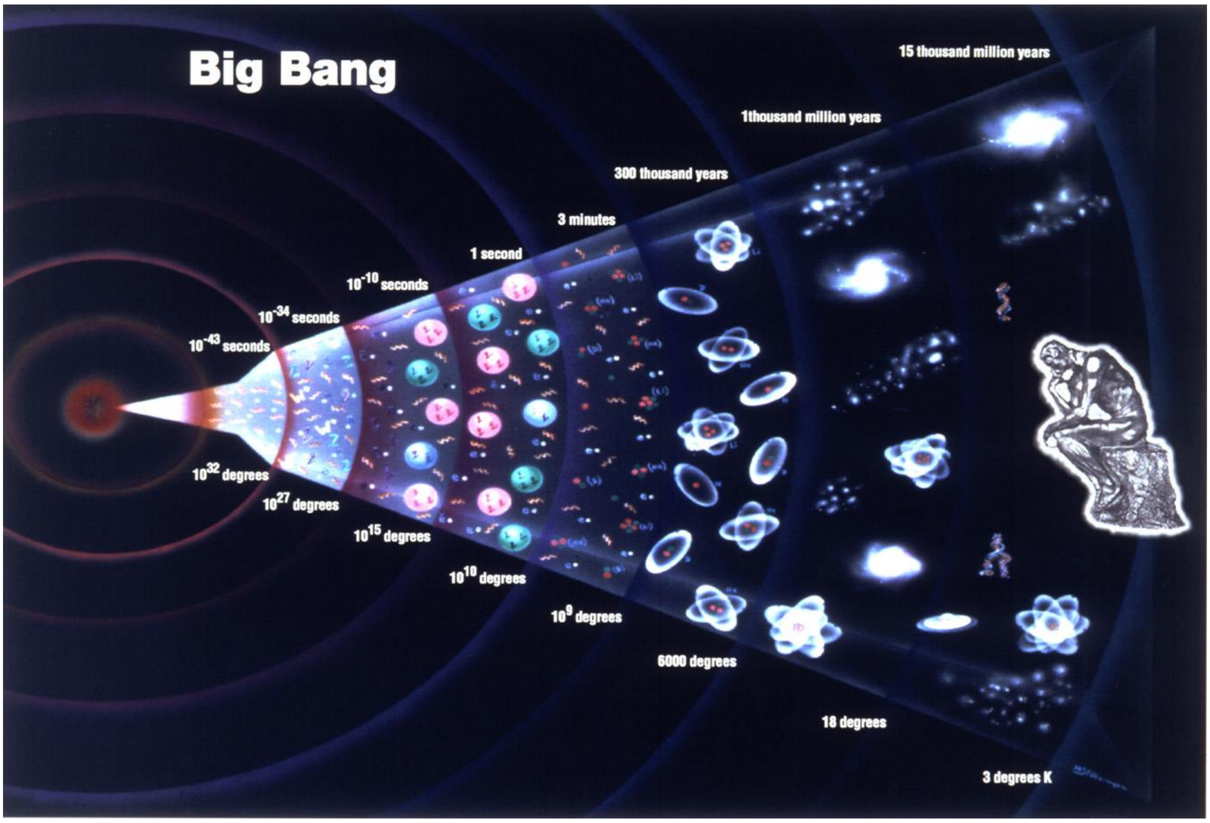
Extension:

1. Calculate the gradient of the graph.
2. The gradient of the graph is the Hubble Constant, H_0.
3. The value of the Hubble Constant is 67.4 km/s/Mpc. How does your value compare?

Extended Extension:

1. Comment on the accuracy of your gradient value compared to the accepted value of the Hubble Constant. What could have caused any inaccuracy?

9P 8d The Big Bang Theory



Watch the video and take some notes in the space below:

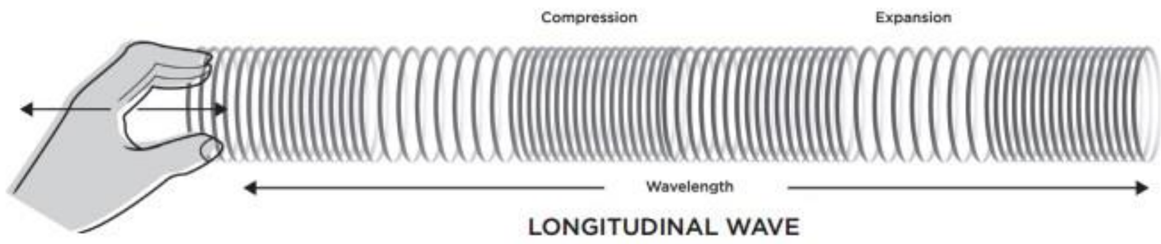
Sound and How We Hear it

One of our most useful senses is our ability to hear sound. But what is sound?
A common question that confuses people is…. "When a tree falls in a forest with no one around, does it make a sound?'

Talk to your neighbour and try to come up with an explanation of what sound is, and try to discuss the tree in a forest.

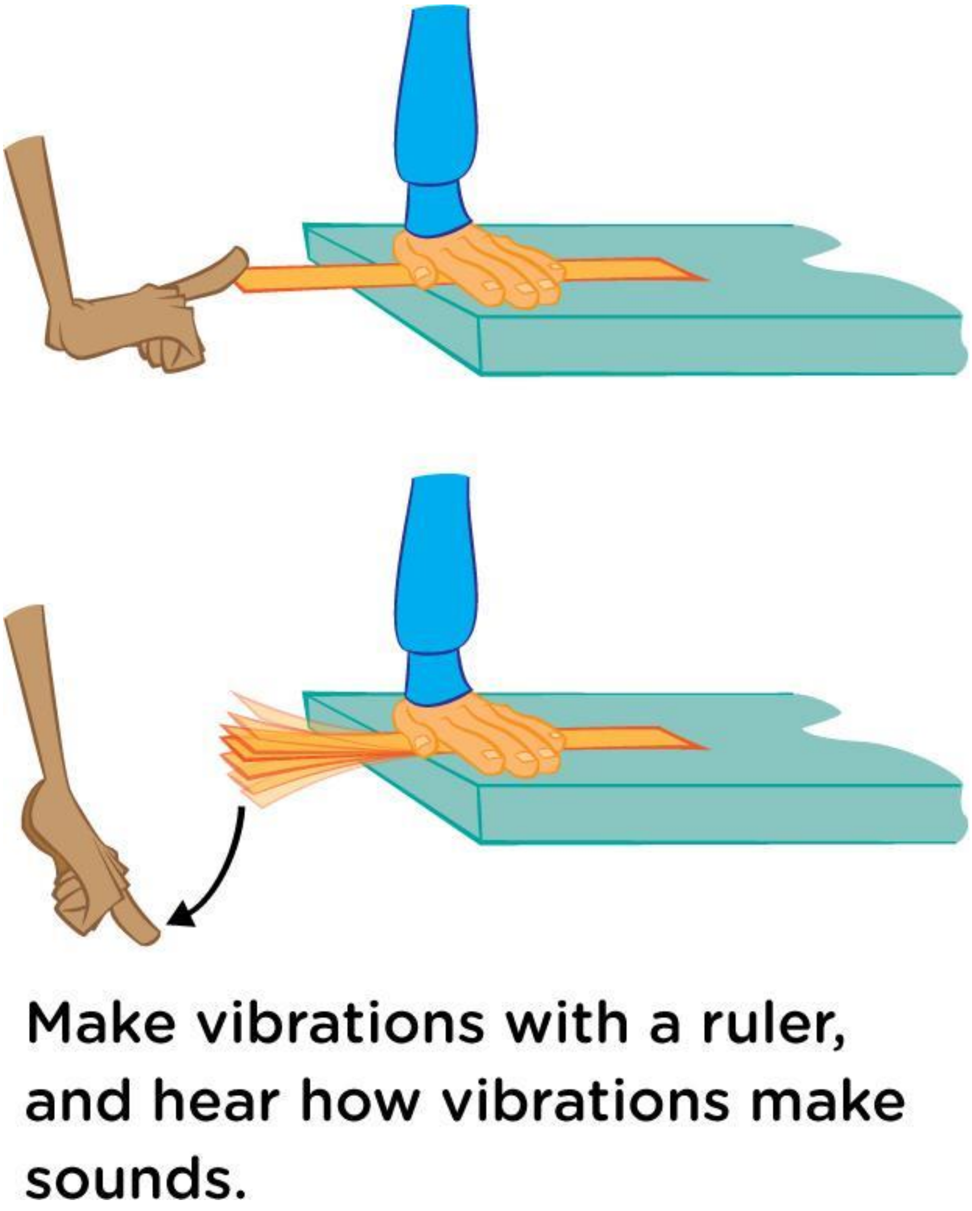
Watch 'What is sound' [1. What is sound-powerpoint.ppt]

This is a Slinky and represents how sound travels through a medium.



Your teacher may let each pair take turns in producing a wave as shown above. This is called a longitude wave and is a demonstration of how air particles behave when transmitting sound.
If you place a small piece of tape in the centre of the spring you can get a better understanding of how the air particles vibrate (or oscillate)

Grab a 50cm ruler, or use your own and try to use it like below to create vibrations and make a sound. Can you make different sounds with the same ruler?



Longitudinal Waves

Fill the gaps to complete the paragraphs describing the properties of longitudinal waves.

Longitudinal waves vibrate, or **o**__________________ , in the same direction as the energy they

are transferring. They transfer energy __________________to the direction in which the waves oscillate.

Longitudinal waves can be modelled by pushing a spring ________________________ .

The energy is transferred horizontally along the spring, in the ___________________ direction

the waves move in. The spring returns to its original position once the energy has been

transferred because waves do not transfer __________________ , only energy. waves are an

example of longitudinal waves.

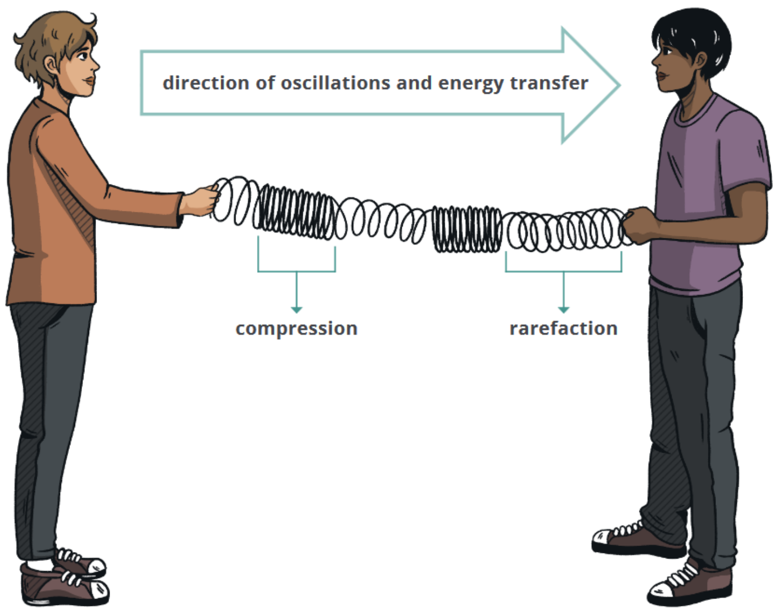
Longitudinal waves contain areas where the particles are closer together than _____________________.

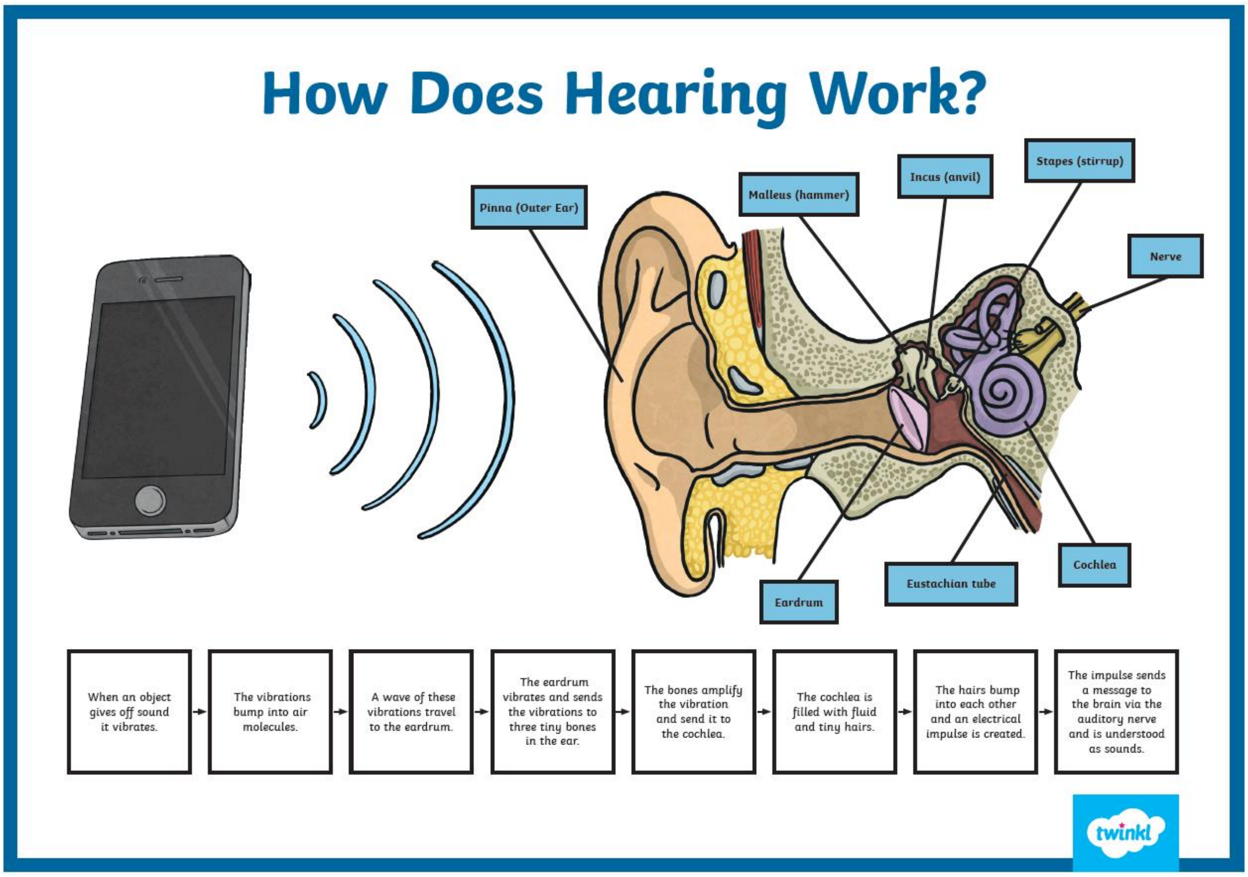
These areas are called _______________________. On a spring, areas of compression are

shown where the coils are closer together. The places on the spring where the coils are

stretched out model ____________________. These are areas on a longitudinal wave where

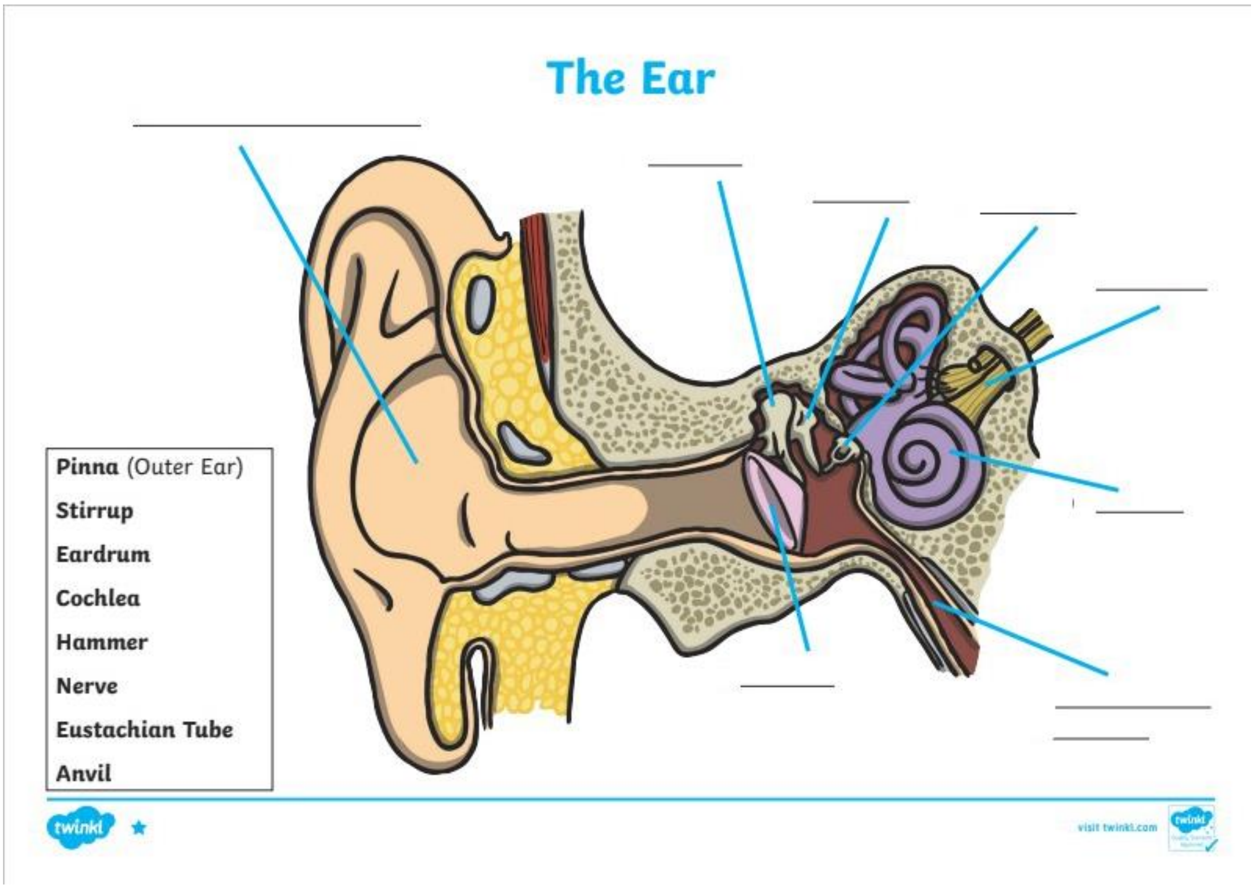
the particles are further apart than average.





After watching [4. Parts of the Ear-powerpoint.pptx] try to fill in the gaps below:

Fun fact: The outer ear (or the Pinna) is one of the only two parts of the human body that never stop growing. What do you think the other part is?



Research further what each of these parts do and find out what can go wrong with the human ear. How has technology come to the rescue?

Further notes on the function of the parts of the ear: What problems can occur in the human ear and how can they be fixed?

9. Whats Your Idea Hearing Aids PowerPoint.pptx

https://docs.google.com/presentation/d/1KZO7iOym5CAZ3Uuf1T4zmQ6MvGwEZXl0/edit#slide=id.p1

Sound travels only when there is a medium to travel in. An example of a medium is air, or water, or metal etc.

Can you think of the name of something that sounds CANNOT travel through?

Wave Speed in Solids, Liquids and Gases

Energy is transferred as sound when particles vibrate against each other. Sound waves require particles to travel. The substance that a sound wave travels through is known as a Medium.

The three states of matter are: solid, liquid and gas. The particles in each of the states of matter are arranged differently.

1. Draw the particle models for a solid, a liquid and a gas in the boxes below.

solid	liquid	gas

2. Compare the arrangement of the particles in solids, liquids, and gases.

____

____

____

____

3. Which state of matter do sound waves travel through most quickly? Explain your answer.

____

Outer space is described as a vacuum. There are no particles in a vacuum.

4. Explain why sounds cannot be heard in outer space.

Speed of Sound

The table below shows the speeds at which sound waves travel through different materials.

Medium	State	Speed of Sound (m/s)
air	gas	343
helium	gas	1007
water	liquid	1498
seawater	liquid	1531
glycerine	liquid	1904
aluminium	solid	3100
steel	solid	3235
glass	solid	3280

Use the information in the table to draw a bar chart showing the speeds at which sound waves travel through different materials. You may like to use a key to show the state of each material.

Use the data table and the bar chart you have drawn to answer the following questions.

1. State the speed of sound in air.

______________m/s

2. Describe the pattern shown in the data table and bar chart.

____

____

3. Use your knowledge of the arrangement of particles in the different states of matter to explain this pattern.

____

____

____

____

Custard is an example of a non-Newtonian fluid. This means it can act like a liquid or a solid depending on the pressure put on its surface.

4. Suggest a value for the speed of sound through custard. Give a reason for your answer.

_____________________m/s

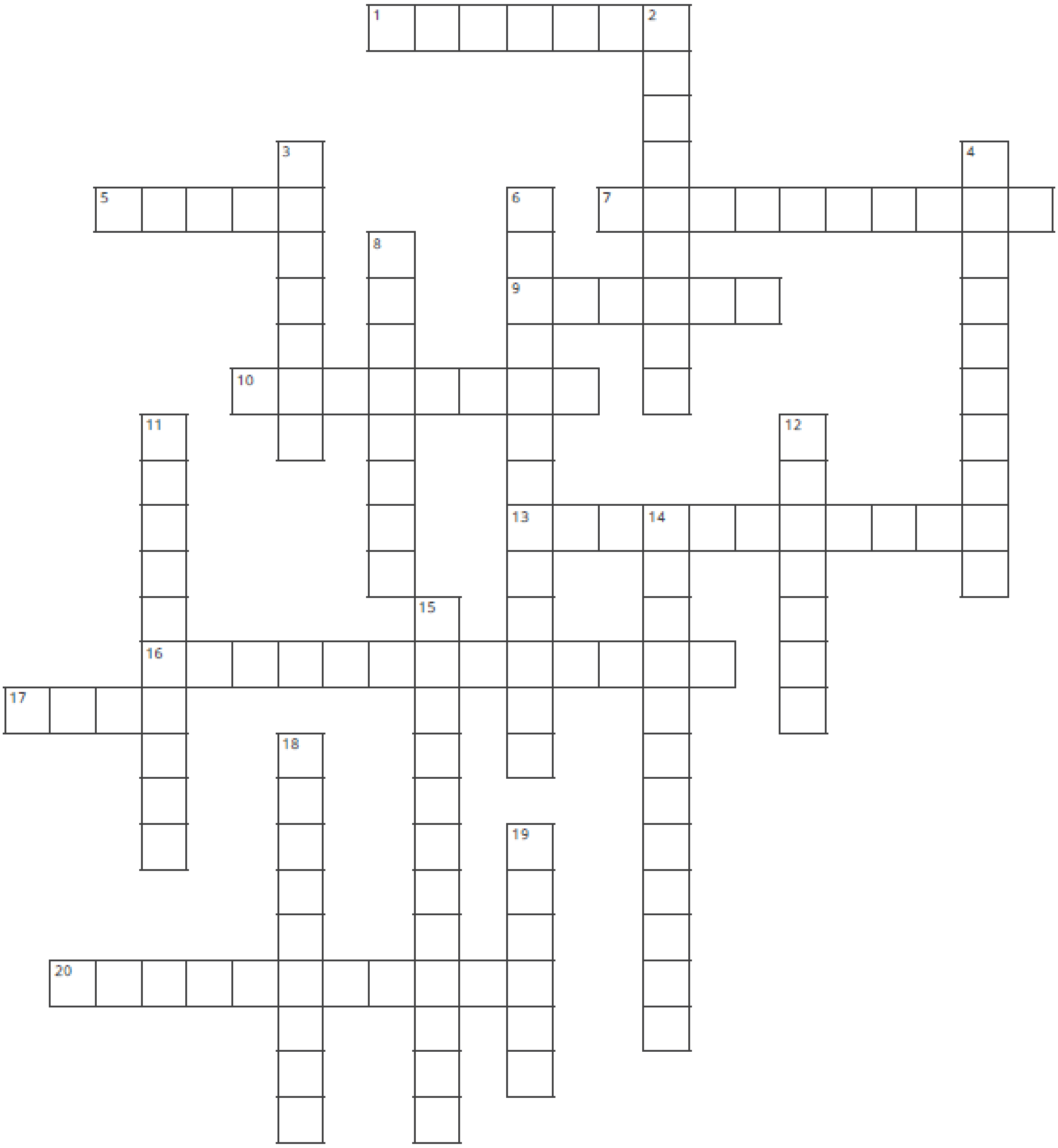
____

____

____

Sound and Hearing **Crossword**

Solve the clues about sound and hearing to complete the crossword. The number at the end of each clue tells you how many letters there are in the answer.



Across

1. The fluid-filled organ of the inner ear which creates electrical impulses. (7)
5. The external part of the ear which funnels sound waves into the ear canal. (5)
7. A device used by singers to convert the vibrations from sound waves into electrical signals. (10)
9. An absence of matter that sound waves cannot travel through. (6)
10. The nerve which transmits electrical impulses from the cochlea to the brain. (8)
13. An area on a longitudinal wave where the particles are further apart than average. (11)
16. The ability of waves to add together or cancel each other out when they travel together or cross a point. (13)
17. A reflected wave. (4)
20. An area on a longitudinal wave where the particles are closer together than average. (11)

Down

2. The distance between the resting position of a wave and the furthest point from it. (9)
3. A thin membrane inside the ear that vibrates when energy is transferred to it from vibrating particles. (7)
4. Sound waves with frequencies below the lower limit of human hearing. (10)
6. The superposition of several echoes. (13)
8. The collective term for the three tiny bones of the middle ear. (8)
11. Sound waves with frequencies above the upper limit of human hearing. (10)
12. The unit for measuring the loudness of sound. (7)
14. Animals like bats and dolphins use this to locate prey and obstacles. (12)
15. Sound waves are an example of this type of wave. (12)
18. The number of waves passing a point each second. (9)
19. The value, in hertz, of the frequency at the lower end of the human audible range. (6)

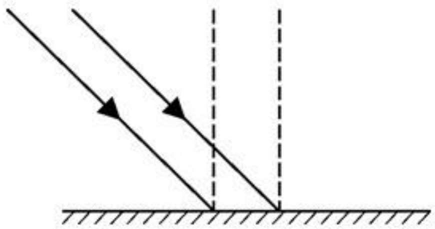
Time for a quiz 10. Sound Waves-Quiz.ppt

https://docs.google.com/presentation/d/1F5pL1Z0lXmBWyaEnkGpfb-UGmBZ0J2mO/edit#slide=id.p1

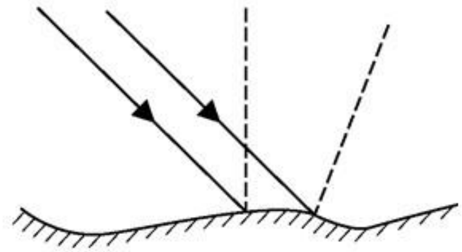
Quick Quiz

1 Complete the rays on the drawings below.

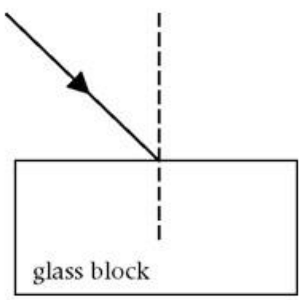
a



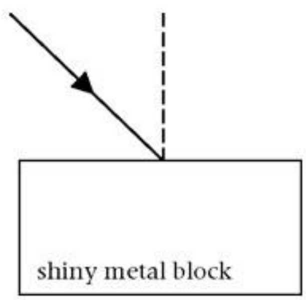
b



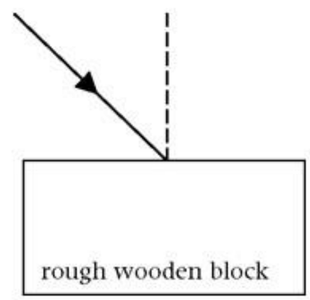
c



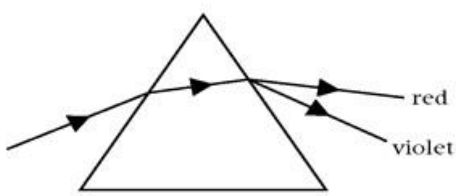
d



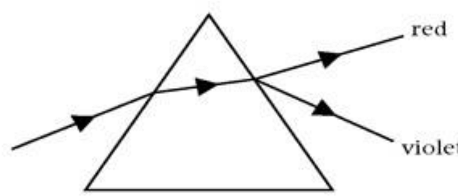
e



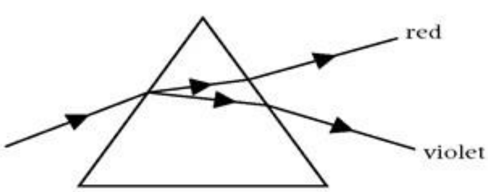
2 Put a tick by the correct diagram.



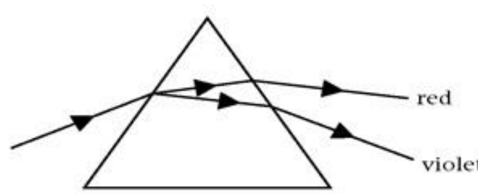
A ☐



B ☐

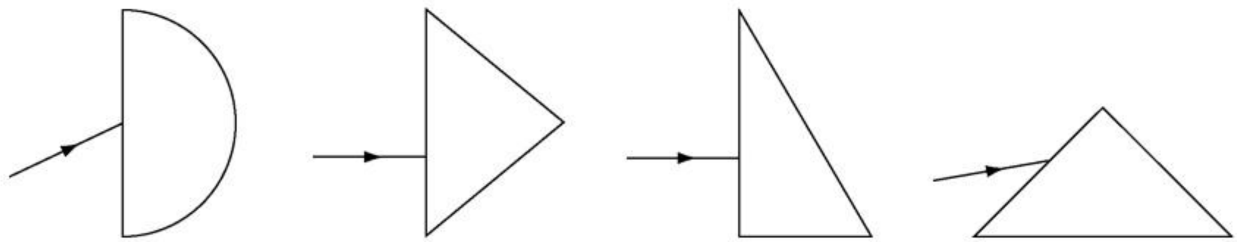


C ☐



D ☐

3. Complete the following ray diagrams



Extension: Find out about the position of visible light in the **electromagnetic spectrum**. How is visible light different to UV, IR, Gamma or X rays?

Summary Sheets

Light

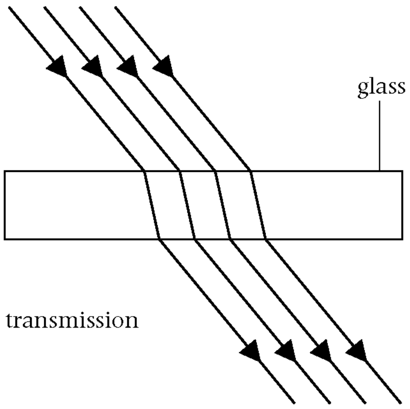
Objects which create light are **luminous sources**. Objects are luminous when they have a high temperature, like the surface of the sun.

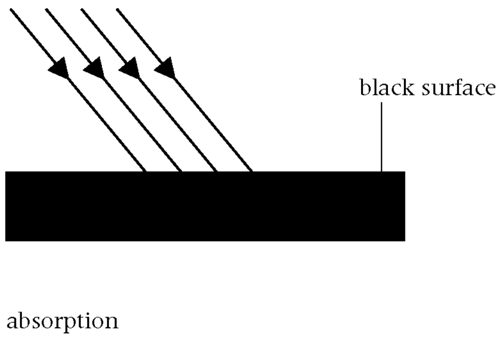
Light travels in *straight* lines.

Light waves travel through **transparent** objects but not through **opaque** objects. **Shadows** are made because light cannot travel through opaque objects. **Translucent** objects show a glow of light through them.

Transmission and absorption

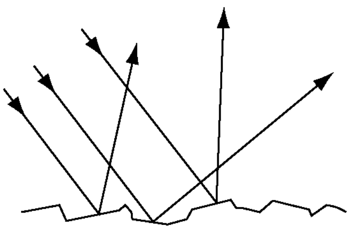
Transparent materials let light pass straight through. We say they **transmit** light. Opaque surfaces can **absorb** light. Black surfaces absorb light very well and reflect very little. This is why they look so dark.



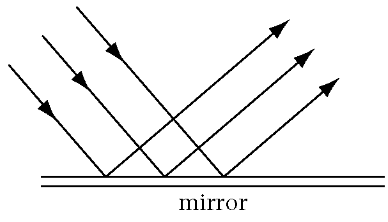


Reflection

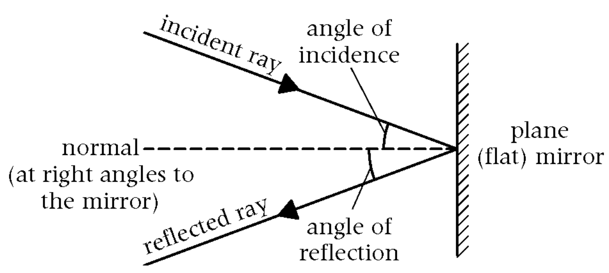
Light rays are **scattered** by rough surfaces, and a **reflection** cannot be seen.



A **plane** mirror is a flat mirror. Light is reflected evenly by a plane mirror.



The **angle of incidence** is equal to the **angle of reflection**.

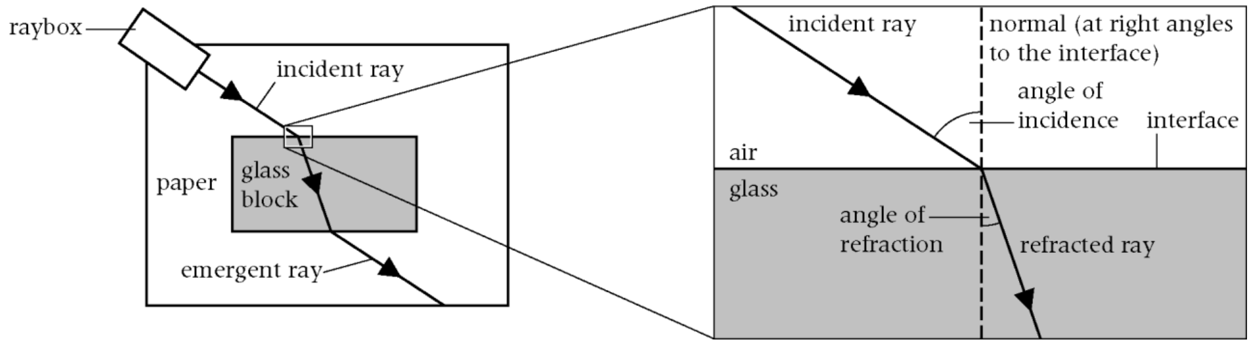


When light shines on to an object viewed in a mirror, the rays are **reflected** into the eye. They seem to come from a position behind the mirror. The **image** is the **same size** as the object and the **same distance** from the mirror. In the image left is right and right becomes left.

Refraction

When light hits something **transparent** it changes direction. This is called **refraction**.

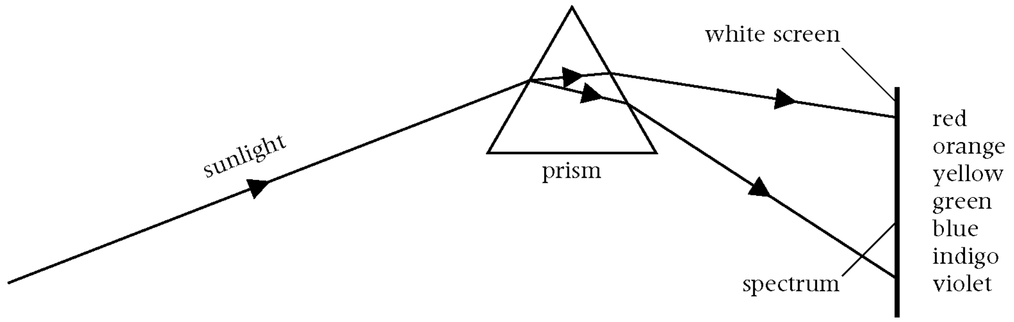
Refraction takes place at the **interface** between two substances. When light is transmitted through glass it slows down and bends towards the **normal**. When it travels back out it speeds up again and bends away from the normal.



Colour

White light is a mixture of colours. White light can be split up using a **prism** to give a **spectrum** of seven visible colours (red, orange, yellow, green, blue, indigo, violet).

The splitting of colour into a spectrum is called **dispersion**.



Different colours can be made by mixing light of the three **primary colours** (red, green and blue).

Coloured light can be made using a **filter**. A red filter lets red light through, but **absorbs** all the other colours.

We are able to see colours because objects do not reflect all the colours in light:

White objects reflect all the colours.
A red object only reflects red and all other colours are absorbed.
This idea applies to all colours except black.
Black objects absorb all colours.

Rainbow

A **rainbow** is produced when water droplets in the air **refract** sunlight.