QUALIFICATION AWAITING ACCREDITATION

OCR
Oxford Cambridge and RSA

GCSE (9–1)
Delivery Guide

GATEWAY SCIENCE PHYSICS A

J249
For first teaching in 2016

Waves in matter

Version 1

Can also be used for teaching:
GCSE (9–1) GATEWAY SCIENCE COMBINED SCIENCE A

www.ocr.org.uk/physics

Introduction

GCSE (9–1)
GATEWAY SCIENCE PHYSICS A

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

QUALIFICATION AWAITING ACCREDITATION

'These draft qualifications have not yet been accredited by Ofqual. They are published (along with specimen assessment materials, summary brochures and sample resources) to enable teachers to have early sight of our proposed approach.

Further changes may be required and no assurance can be given at this time that the proposed qualifications will be made available in their current form, or that they will be accredited in time for first teaching in 2016 and first award in 2018.

Curriculum content

Subtopic 1 – P5.1 Wave behaviour

P5.1a	describe wave motion in terms of amplitude, wavelength, frequency and period
P5.1b	define wavelength and frequency
P5.1c	describe and apply the relationship between these and the wave velocity
P5.1d	apply formulae relating velocity, frequency and wavelength
P5.1e	describe differences between transverse and longitudinal waves
P5.1f	show how changes, in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related
P5.1g	describe the effects of reflection, transmission and absorption of waves at material interface
P5.1h	describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids
P5.1i	explain why such processes only work over a limited frequency range, and the relevance of this to human hearing
P5.1g	describe the effects of reflection, transmission and absorption of waves at material interface
P5.1h	describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids
P5.1i	explain why such processes only work over a limited frequency range, and the relevance of this to human hearing
P5.1j	describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured
P5.1k	describe evidence that in both cases it is the wave and not the water or air itself that travels

Learners should already be familiar with the basic concept of a wave; this topic will introduce them to reflection, refraction, diffraction and absorption in both mechanical and electromagnetic waves. It will also approach the evidence which originally led scientists to deduce that light was a wave. Learners should also be aware of the equations governing all waves: wave speed (m/s) = frequency (Hz) x wavelength (m), and the important difference between mechanical waves, which require a medium to travel through, and electromagnetic waves, which do not.

General approaches:

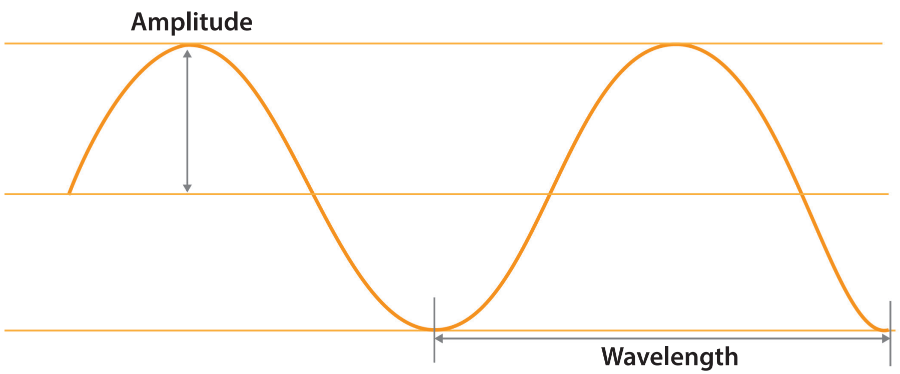
Learners should be familiar with waves from the KS3 topics Light and Sound. Revisiting key language at the start of the topic may be of benefit here: such as wavelength, amplitude, frequency and Hertz (Hz).

Learners should understand that waves transfer energy. Some waves need a medium to travel through, such as sound waves, or longitudinal waves whilst others can travel through a vacuum, such as light waves or transverse waves.

This topic offers lots of opportunities for hands on practical work and demonstrations, which will help to engage learners. A circus of activities could be a great way to revisit KS3 knowledge without taking up too much lesson time.

Diagrams are a useful way for learners to see the differences in amplitude, wavelength and frequency and relate these to the differences in sound they hear. An oscilloscope offers learners this opportunity.

When a wave is produced it disturbs particles. A bigger vibration will disturb particles more than a smaller vibration, and this can be understood by a loud or quiet sound respectively. Amplitude can be defined as the maximum disturbance of a wave from its undisturbed position; the more vibrations made, the louder the sound and therefore the higher the amplitude. Wavelength is the distance between two identical points on a wave, the period is the time taken for one complete wave to pass a certain point, and frequency is the number of waves produced every second, or the number of waves (characterised by one wavelength) that passes a certain point every second.



Wave speed or wave velocity is related to frequency and wavelength via the following equation:

Wave speed = frequency x wavelength

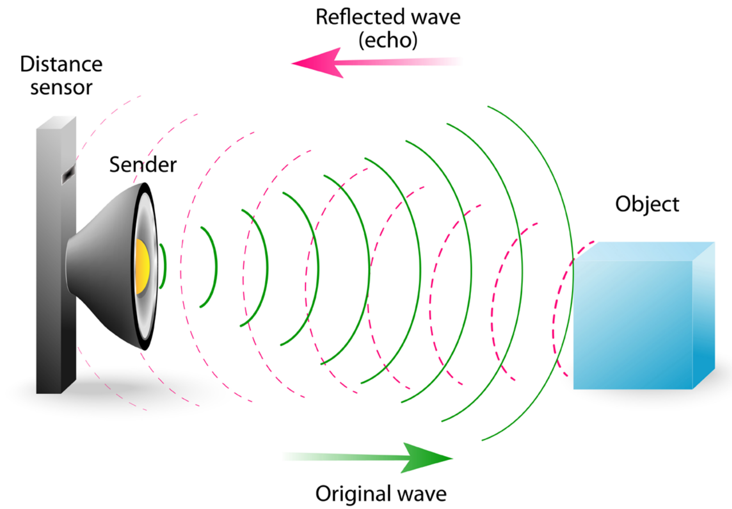
The differences between transverse and longitudinal waves are best seen from diagrams and simulations. Learners should understand that with transverse waves, vibrations are at right angles to the directions of travel and energy transfer. With longitudinal waves the oscillations, or vibrations, travel in the same direction as the energy transfer. Longitudinal waves show areas of compression, where the particles are close together, and areas of rarefaction where particles are spread out. These can be seen in the simulations detailed in the activity section.

Learners also need to understand how waves behave when they travel between two mediums, or reach a surface. Reflection and refraction of light should be familiar through KS3 studies, and this can be used as a basis to move forward at GCSE level.

Reflection

Reflection of light should have been covered in KS3 but the topic is worth revisiting in order to demonstrate the differences/similarities in light and sound waves.

Sound waves can be reflected from hard, flat surfaces. We sometimes hear this as an echo when the two sounds overlap.



Animals use this to hunt for prey.

Ultrasonic echoes can be used as a measuring tool. If we refer to the equation on the previous page, such a high frequency means the wavelength of the sound wave is very small. Sound waves can be reflected back by small objects, echoes can be timed and the distance to the object calculated. Examples of how ultrasonic echoes are used include searching for oil and gas, checking the health and development of foetuses, to check for tumours, investigating heart and liver problems and to break up kidney stones.

Refraction

When waves arrive at a boundary between two different media at an angle, the velocity changes and causes the wave to change direction. Learners should be familiar with conducting this experiment at KS3. A useful analogy to use here is a car driving on tarmac and then on mud at an angle. The change in material causes the car to slow down and change direction. Sound travels at different speeds in solids, liquids and gases. The wavelength and hence velocity of the sound wave changes: the velocity is directly proportional to the wavelength. Thus if the wavelength doubles, the velocity doubles. Revisiting the equation above may help to demonstrate this relationship.

The human ear

A good way to move on from the frequency range of animals is to compare them to our own hearing range. Again, some knowledge is expected from KS3 studies, and a task whereby learners annotate and describe parts of the ear via a diagram is a great way to elicit what learners already know.

Common misconceptions or difficulties learners may have:

Some learners find an increase in scientific terminology hard to grasp, and therefore repetition of and use of key language in this topic is essential.

The direction of travel of a transverse wave is also hard for learners to see. Simulations offer some clarity, but the use of a piece of ribbon or skipping rope can illustrate this idea very well. Conversely, a slinky is a great tool to demonstrate how longitudinal waves travel, and learners can see the clear difference between these two types of wave.

Learners can sometimes confuse reflection and refraction. When discussing changes of velocity in sound waves travelling through two different media, learners may wonder why frequency does not change. The frequency of a sound is determined by the source of the sound, not the medium through which it travels.

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Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

We revisit transverse waves when we introduce the electromagnetic spectrum so it is important that learners understand the differences between transverse and longitudinal waves, and know the characteristics of transverse waves from the beginning of the topic.

Approaches to teaching the content

Light and sound are all around us so this topic lends itself very well to engaging learners with what they can experience around them. Excerpts from learners' favourite music can be used to test their knowledge about oscilloscope readings and sound characteristics (especially amplitude and pitch).

The behaviour of light at different boundaries can be used to explain our mirror reflections.

Demonstrating how longitudinal waves lose energy – your voice at the front versus back of the class.

Q. Why do actors need to project their voices on stage?

Activity 1
Waves

Physics classroom

http://www.physicsclassroom.com/class/waves

This page has a range of information, mathematical practise questions and tests to introduce you to Waves. Not all information is relevant but much of it is very useful.

Activity 2
Waves on a string

Phet Colorado

http://phet.colorado.edu/en/simulation/wave-on-a-string

This simulation allows you to change the amplitude and frequency and see the changes. Opt for the loose end option and oscillate.

Activity 3
Transverse and longitudinal waves

Animated Science

http://www.animatedscience.co.uk/blog/wp-content/uploads/focus_waves/tl-wave.html

Another simulation to show how transverse waves travel, but they can also be compared to longitudinal waves too.

Activity 4
Refraction of Light

TES

https://www.tes.co.uk/teaching-resource/refraction-6314916

This PowerPoint and exit card is a great idea of how to structure a lesson on refraction. Some learners may need more specific instructions of how to measure angles, but the idea can be adapted to suit the needs of the class.

Activity 5
Measuring refractive index

IoP

http://tap.iop.org/vibration/reflection_refraction/page_39796.html

On the page scroll down and look for activity TAP 317-2. The link takes you to a full set of learner instructions for carrying out this practical.

Activity 6
Measuring the wavelength of light

Nuffield Foundation

http://www.nuffieldfoundation.org/practical-physics/measuring-wavelength-light

This activity allows learners to get hands on with an element that is usually very theoretical.

Activity 7
Transverse waves along a rope & pulses and continuous waves with a slinky spring

Nuffield Foundation

http://www.nuffieldfoundation.org/practical-physics/transverse-waves-along-rope

http://www.nuffieldfoundation.org/practical-physics/pulses-and-continuous-waves-slinky-spring

An instructional resource with some key teaching notes of how to deliver this in class. The transverse page comes with a link to a video demonstrating the same phenomena on a wave machine.

Activity 8
Mirror maze activity

TES

https://www.tes.co.uk/teaching-resource/reflection-of-light--mirror-maze-6325368

This fun task helps learners to practise measuring angles of reflection.

Activity 9
Reflection

TES

https://www.tes.co.uk/teaching-resource/the-law-of-reflection-6338652

A simple set of instructions which can be easily adapted for the needs of any class.

Activity 10
Estimating wavelength, frequency and velocity of ripples

Nuffield Foundation

http://www.nuffieldfoundation.org/practical-physics/estimating-wavelength-frequency-and-velocity-ripples

A set of practical instructions how to estimate the velocity of ripples.

Activity 11
Hearing and age

NIH

http://www.nidcd.nih.gov/health/hearing/Pages/Age-Related-Hearing-Loss.aspx

A great website detailing how we hear and why hearing is reduced as we age.

P5.2a	recall that electromagnetic waves are transverse and are transmitted through space where all have the same velocity
P5.2b	explain that electromagnetic waves transfer energy from source to absorber
P5.2c	apply the relationship between frequency and wavelength across the electromagnetic spectrum
P5.2d	describe the main grouping of the electromagnetic spectrum and that these groupings range from long to short wavelength
P5.2e	describe that our eyes can only detect a limited range of the electromagnetic spectrum
P5.2f	recall that light is an electromagnetic wave
P5.2g	give examples of some practical uses of electromagnetic waves in the radio, micro-wave, infra-red, visible, ultra-violet, X-ray and gamma-ray regions
P5.2h	describe how ultra-violet waves, X-rays and gamma-rays can have hazardous effects, notably on human bodily tissues
P5.2i	explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in our bodies
P5.2j	recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

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General approaches:

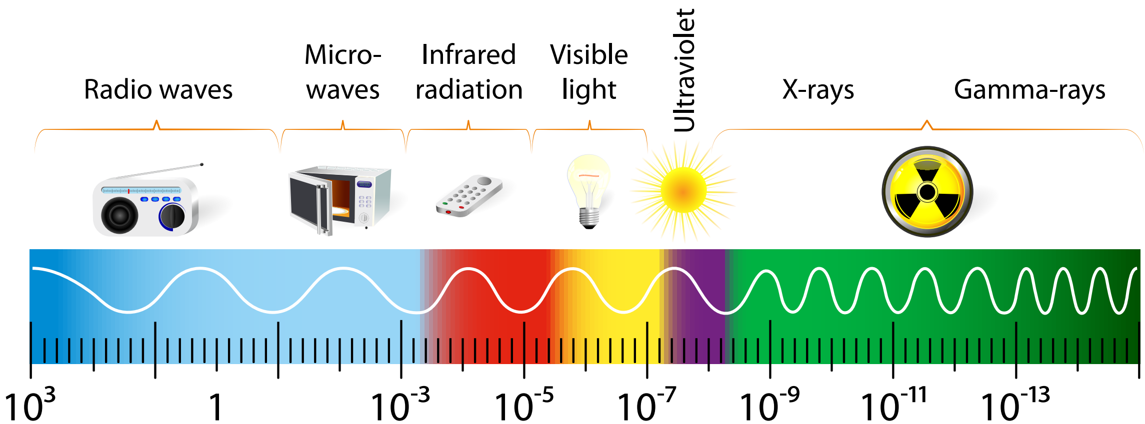
The electromagnetic spectrum can be taught as an extension of light. Once learners see an illustration of the spectrum they can start to make links between the characteristics of light and the rest of the spectrum. It is important that learners understand that visible light is part of the EM spectrum, even though previously taught in isolation. Sound is not part of the EM spectrum.

Learners will have come across some of the other types of waves before: microwaves, X-rays, Gamma rays, radio waves and so a task to measure what learners already know will highlight misconceptions as well as illustrate previously gained knowledge.

When discussing the behaviour of the EM spectrum, it important to revisit how light behaves. The EM spectrum is governed by the same laws as light.

The use of diagrams, card sorts and cut and stick activities are a great way to engage learners in learning about the different groups of the EM spectrum. Learners will get to know how frequency and behaviour and use of a group are related. A useful way to encourage learners to learn about each group of the spectrum is for learners to research a particular group and then team teach it to the rest of the class. **See details in activity section.**

THE ELECTROMAGNETIC SPECTRUM



Common misconceptions or difficulties learners may have:

Learners may confuse differences between the parts of the spectrum with differences in velocity. According to the equation velocity = frequency x wavelength learners may assume that the speed of the EM spectrum changes because the frequencies and wavelengths do. In fact the speed of the EM spectrum stays constant; the frequency and wavelength of each part of the spectrum is inversely proportional. As wavelength decreases, frequency increases and vice versa.

Electromagnetic spectrum is not related to electro-magnets, which learners may have previously studied.

The term radiation is often used interchangeably. Be sure to clarify that whilst all parts are known as radiation, only the high energy groups are examples of ionizing radiation.

Approaches to teaching the content

Learners will have experienced many of the groups of the EM spectrum: from radio waves, microwaves to UV rays and X rays. Asking learners to bring in any X rays they have, or if the teacher has any will help to engage the learners.

Explaining how Bluetooth or airdrop works on mobile phones (through the use of radio waves). If mobile phones are allowed in the classroom this could be used to send a file from a volunteer's phone to the rest of the class to demonstrate how science is evident in everyday life.

Fibre optics is a great way to illustrate how the reflection of light can be used to develop new surgery tools. Many learners will know someone who has experienced keyhole surgery. Learners may have previous experience of infrared when studying KS3 Heating and Cooling. Learners can interpret infrared images, and understand how police use infrared cameras. Often a delicate topic but some learners/staff may know people who have had cancer treatment via gamma rays.

Activity 1
Electromagnetic spectrum card sort

TES

https://www.tes.co.uk/teaching-resource/p1-electromagnetic-spectrum-card-sort-6171317

A card sort that learners can use as a research task with a range of informative resources, or as a revision tool.

Activity 2
The Electromagnetic Spectrum

Andy Darvill

http://www.darvill.clara.net/emag/emaggamma.htm

This informative website details useful information about each group of the EM spectrum in line with the GCSE specification, with revision of key terms such as wavelength and frequency.

Activity 3
Hearing the Doppler Effect

IoP

http://supportingphysicsteaching.net/Ra01TA.html#TA0

An in depth source with information of how to prepare for the task, and what happens during the task.

Activity 4
EM Spectrum

Teacher Resource: www.ocr.org.uk/Images/288967-waves-in-matter-teacher-resource.doc and Learner resource: www.ocr.org.uk/Images/288966-waves-in-matter-learner-resource.doc

This learner lead activity provides learners with the opportunity to research and deliver key information about one of the groups of the EM spectrum.

P5.3a	recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength
P5.3b	explain how some effects are related to differences in the velocity of electromagnetic waves in different substances
P5.3c	use ray diagrams to illustrate reflection, refraction and the similarities and differences between convex and concave lenses (qualitative only)
P5.3d	construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative only –equations not needed) (M5a, M5b)
P5.3e	explain how colour is related to differential absorption, transmission and reflection

This topic introduces reflection, refraction and diffraction, as well as exploring the behaviour of materials that react differently to different frequencies of light and sound. In much the same way as we saw that the atmosphere transmits, reflects and absorbs various frequencies within the electromagnetic spectrum, coloured objects reflect, transmit and absorb different frequencies of visible light.

General approaches:

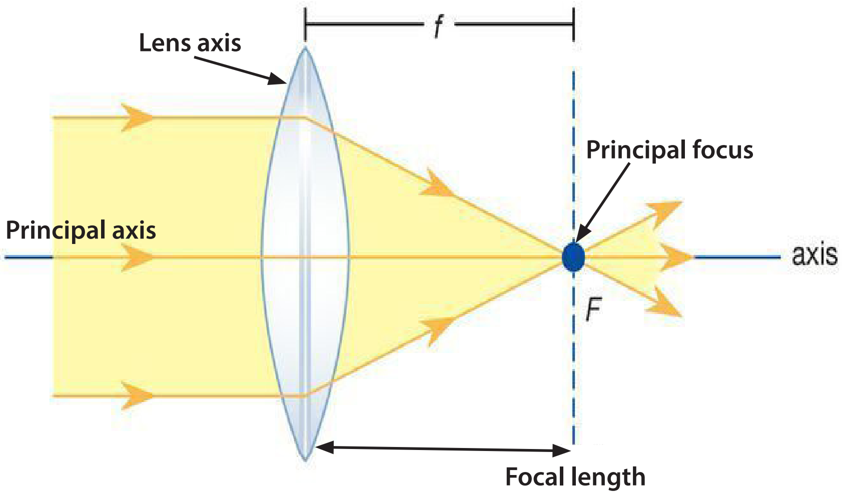
This sub topic is both revision and an extension of previous wave subtopics, and so is a great opportunity to consolidate previously learnt information, with new information such as light behaviour on a lens.

A good place to start is by revisiting what learners know about visible light: here they may offer knowledge on wavelength and frequency, but may also illustrate their knowledge from KS3 studies on colour, reflection and refraction which can drive the learning outcomes. A quick revision of refraction at a glass prism will give learners a basis to learn the differences of refraction at both concave and convex lenses. There is some new terminology here, and learners need to be familiar with terms such as principal focus, focal length and how lenses form virtual and real images. Learners need help in relating ray diagrams to real world situations, and move beyond the theory to help them understand light behaviour.

It is worth telling learners that a thick/fat lens is a strong lens with a short focal length, and a thin lens is a weak lens with a long focal length.

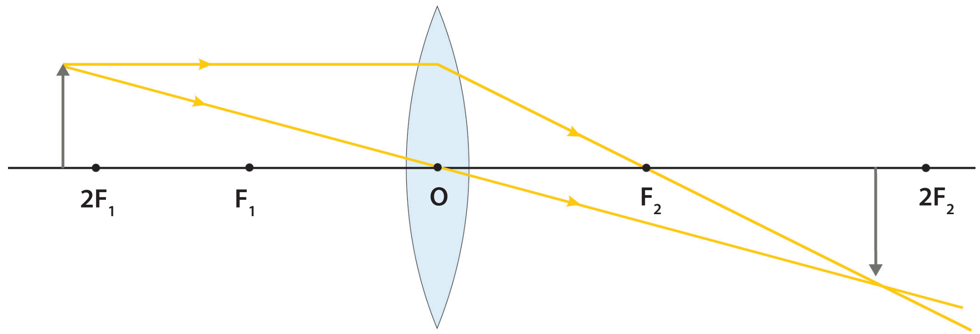
It is also important to highlight that light travelling through the centre of the lens continues in the same direction, and is not refracted (see centre ray in diagram below).

When constructing ray diagrams with a convex lens, it is important to start off by identifying the principal focus.

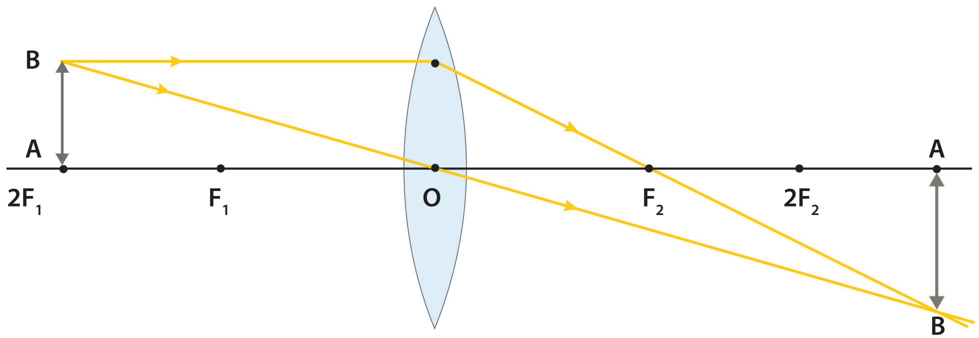


To show how images are produced at varying distances the following ray diagrams can illustrate different light behaviours.

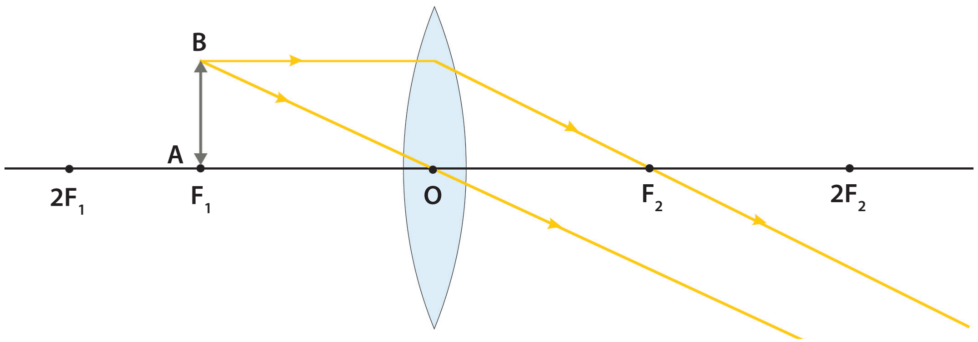
A distant object more than double the focal distance away (2F): This image would be inverted and real.



An object between F and 2F (the focal distance and double the focal distance): this image would be inverted, real and magnified.



An object inside the focal distance (F): This image would be upright and magnified. Uses of this include magnifying glasses, telescopes and lenses in glasses for long-sighted individuals.



Colour

Refraction, wavelength and frequency all come together when learners learn about colour. It is the last concept learners learn in the topic and therefore a useful way for learners to consolidate knowledge from the very beginning of the Wave topic in a more investigative style of learning.

Learners can be given key diagrams and words in order to answer open questions such as:

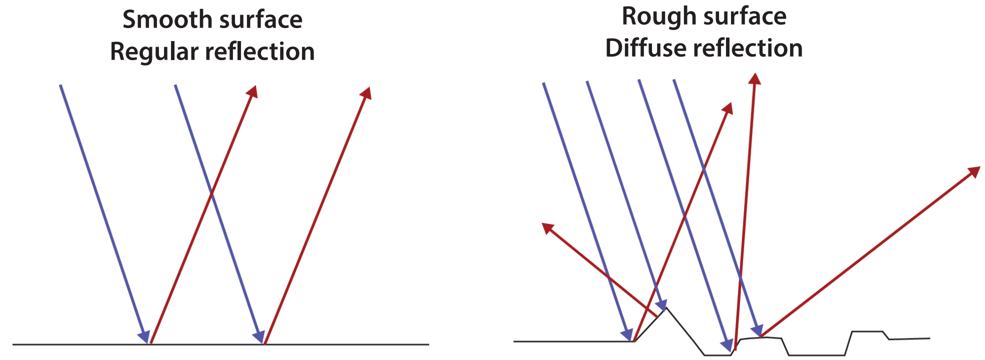
Q. Why do we see different colours?

Q. Why is this object 'blue' and this object 'red'?

Learners should come up with ideas surrounding refraction, wavelengths, white light spreading out, reflection and absorption. Less able learners may need more direction with this.

Here, new terminology is introduced in the form of specular and diffuse reflection, or scattering. Learners should know how light reflects off a plane surface, such as a mirror, and this is specular reflection: when the angle of reflection can be predicted.

Scattering is when the reflective surface is not smooth, on a microscopic level. The reflected rays are therefore not reflected at the same angle as the incident rays.



We see the colour of an object because that colour (or mixture of colours) is reflected into our eyes, the other colours of the spectrum are absorbed. For example, we see a red hat because the fabric reflects the 'red' frequency of the spectrum of light. The other colours of the visible spectrum are absorbed, and do not reach our eyes.

When red light is shone on a blue object the object appears black. This is because the red light is absorbed (only blue light would be reflected) so no light is reflected back.

Higher Tier: The same principle can be applied to the rest of the EM spectrum. Different substances absorb, transmit, reflect and refract EM waves that vary with wavelength.

Common misconceptions or difficulties learners may have:

Literature often uses the term concave, convex, diverging and converging lenses interchangeably. It is important therefore that learners know and learn all the terms. A convex lens is also known as a converging lens, with the rays of light reaching a principal focus (they all meet in one place). A concave lens is known as a diverging lens, spreading the light rays out.

Some may think that light gets dimmer because light is absorbed by objects in its path, in fact the intensity of light decreases simply because it spreads out.

Learners can become confused when drawing ray diagrams so it is important to link it to real world situations where possible.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

Prior knowledge of light behaviour is essential to move forward with how light behaves at different lenses.

Approaches to teaching the content

Lenses are a great way to show how science is shaping our everyday behaviour. An eye dissection may help learners to come up with ideas of how the lens in the eye works, after doing some ray diagrams. It can be explained to learners that the muscles that surround the lens either flatten or thicken the lens depending on how far away objects are that we are trying to see, so that an image we see (which is upside down) is sharply focussed on our retina. This can be related to lens strength and focal length.

Learners can conduct research as a homework task to investigate how glasses and contact lenses correct our vision.

Magnifying glasses, cameras and telescopes are also examples of how lenses are used in every day applications.

Learners may have been in a car when the glare from the sun on a wet road makes it almost impossible to see. This is due to fact that normally diffuse reflection allows us to see the road, yet when wet, a plane surface is created which causes the light to be reflected back into our eyes, causing the glare.

Activity 1
Image Formation with a Lens

IoP

http://practicalphysics.iopconfs.org/image-formation-lens.html

This demonstration uses simple apparatus to form a virtual and real image.

Activity 2
Experiments with a fan of rays

IoP

http://practicalphysics.iopconfs.org/experiments-fan-rays.html

Using a ray box to see the behaviour of light at a convex and concave lens.

Activity 3
Radiations and Radiating

IoP

http://supportingphysicsteaching.net/RaHome.html

This contents page is divided into different sections of the topic, some of which will not be relevant, and links to physics descriptions, teaching and learning issues and teaching approaches.

Activity 4
Lenses

IoP

http://supportingphysicsteaching.net/Ra01PN.html#PN4

A definitions and description of lenses and how they make light behave.

Activity 5
Teaching lenses

TES

https://www.tes.co.uk/teaching-resource/teaching-lenses-6111250

A set of three worksheets introducing convex lenses, with practical sheets to go alongside for learners to complete.

Activity 6
Which ray diagrams are right? – Lenses

TES

https://www.tes.co.uk/teaching-resource/which-ray-diagrams-are-right--lenses-6212782

An activity for learners to identify correct ray diagrams.

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