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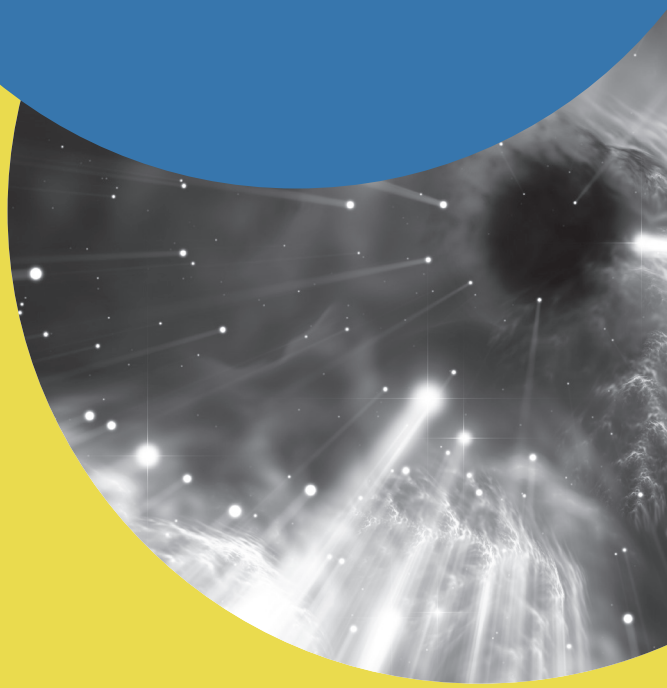


AQA GCSE (9-1)

Physics

Teacher Pack

Advance draft material for the 2016 specifications

Series editor: Ed Walsh

How the lesson plans work

Every chapter and every lesson plan follows the same structure.

Chapter introductions

- give an overview of the content and skills covered in the chapter
- help in assessing prior learning and identifying misconceptions
- list the overarching learning objectives to help medium-term planning.

Learning objectives and outcomes

- **Learning objectives** for each topic are listed and also shared with students in the Student Book for short-term planning.
- **Learning outcomes** at three levels are listed, and it is shown which learning activities contribute to achieving each outcome.
- **Skills development** show how the lesson will develop aspects of working scientifically.

Resources needed and digital resources

These give an overview of all the resources needed for a lesson. Every lesson has an associated differentiated worksheet to support written work. Practical sheets are provided to give support for planning, carrying out and analysing practical work. Technician's notes are provided to explain the materials and setup and help with planning. These can be downloaded from the Collins website at www.collins.co.uk/GCSEscience.

Key vocabulary

This is highlighted throughout to support literacy.

Teaching sequence

The lesson plans all use the same learning sequence. This is based on the idea that learning develops in stages during a lesson and that different parts of the lesson have different functions. In addition to the learning cycles, the lesson plans all have three levels of differentiation: low, standard and high.

- **Engage** This section draws students in to thinking about the ideas, and includes possible starter activities. Here students encounter ideas that will make them want to find out more.
- **Challenge and develop** Students meet something that will challenge their existing understanding. It might be questions, ideas, demonstrations or experiments that make them realise the inadequacy of a simpler explanation.
- **Explain** Students are encouraged to develop a good explanation and supported in capturing ideas in words or graphically. Differentiation ideas are given for students making less or more than expected progress.
- **Consolidate and apply** Students realise how the new learning is to be consolidated and applied, including real-world applications. Again, differentiation ideas are given for students making different levels of progress.
- **Extend** Addresses how the ideas of the topic can be extended to stretch students able to progress further.
- **Plenary suggestions** Varied activities help in gauging student progress.
- **Answers** All answers to worksheet questions are provided.

Waves: Introduction

When and how to use these pages

This unit: will build on ideas the pupils have met before, such as:

All waves have certain things in common:

- They transfer energy from one place to another.
- When waves meet they can add together or cancel out.
- When waves hit an object they may be absorbed by it or transmitted back.
- They may change direction at the point where two different materials meet.

Overview of the unit

In this unit, pupils will learn about light and sound as examples of waves. They will discover why light and sound are different types of waves and be able to give some further examples of both transverse and longitudinal waves. They will investigate the behaviour of waves and learn about some applications of waves in medicine and other situations.

This unit offers a number of opportunities for the pupils to investigate phenomena through practical work, work collaboratively with peers and critically evaluate evidence before drawing conclusions.

Obstacles to learning

The pupils may need extra guidance with the following terms and concepts:

- There may be some confusion between the everyday use of the term ‘wave’ (in terms of a hand wave) and the definition required.
- Common misconceptions:
  - Sounds cannot travel through solids and liquids.
  - Matter moves along waves / waves move matter (as waves in the sea move sand around).
  - Big waves travel faster than small waves (in the same medium).

Practicals in this unit

In this unit pupils will do the following practical work:

- Required Practical: investigating how light reflects off different surfaces
- Measuring the speed of a water wave
- Making a periscope to investigate the law of reflection
- Investigating the path of a light ray through a glass block
- Discover the critical angle of Perspex and use it to solve a further problem.

	Lesson title	**Overarching objectives**
1	Key concept: Transferring energy or information by waves	To research an application of using waves to transfer energy
2	Describing waves	To describe the features of a wave such as frequency, wavelength, amplitude and time period
3	Maths: Solving equations	To rearrange and apply the wave equation
4	Transverse and longitudinal waves	To distinguish between transverse and longitudinal waves and to give examples of each type of wave
5	Measuring wave speed	To explain how the speeds of waves in air and water can be measured
6	Reflection and refraction	To describe reflection, refraction and total internal reflection
7	Required practical: Investigating how light reflects off different surfaces	To investigate the behaviour of light
8	Sound	To explain how we hear sounds and how sound travels in different media
9	Exploring ultrasound	To describe how ultrasound is used for imaging
10	Using ultrasound	To describe how ultrasound can be used to effect a change, rather than simply providing an image
11	Seismic waves	To describe waves in the Earth and to state what we can learn about the structure of the Earth from studying these waves

Waves: Lesson 1

Lesson overview

Learning objectives

- To review the key words associated with waves
- To describe some applications of waves transferring energy
- To link the properties of waves to their uses

Learning outcomes

- To use the key words in the correct context [O1]
- To research a given application [O2]
- To present research findings clearly [O3]

Skills development

- Development of scientific thinking, through researching the timeline of laser development
- Analysis and evaluation, through research and drawing conclusions from research
- Presenting findings, through giving a presentation following their research

Resources needed Worksheet 2.1.1, worksheet 2.1.2, worksheet 2.1.3, access to research material (probably online)

Key vocabulary frequency, amplitude, wavelength, peak, trough, longitudinal, transverse, pitch, laser, electromagnetic spectrum

Teaching and learning

Engage

- Ask pupils to **discuss** the following question: 'A torch beam transfers 10,000 times more energy than a laser beam. Why are lasers far more dangerous than torches?' Take feedback from a number of pairs to **develop** the ideas amongst the group. [O1]
- Alternatively, ask the pupils to **list** the uses of lasers that they have heard of / use in their everyday lives. You could ask them to **suggest** why lasers can be used to repair eye sight. [O1]

Challenge and develop

- The pupils should each be given one of the following aspects to **research** and **present** to their peers:
  - Low demand: what are waves? (an introduction to waves) – worksheet 2.1.1. [O1 and O2]
  - Standard demand: research the use of waves in the form of lasers – worksheet 2.1.2. [O1 and O2]
  - High demand: research the different types of wave in the electromagnetic spectrum and give a use for the different types of wave – worksheet 2.1.3. [O1 and O2]

Explain

- Regroup the students so that there is a pupil from each research group now working together. They should **present** their findings to the rest of the group. During the presentations, the rest of the group should **peer mark** against the success criteria outlined on the research briefs. [O3]
- Alternatively, a select number of pupils should **present** their findings to the rest of the class. The rest of the class could be given an opportunity to **question** the presenter, before **peer marking** their work against the success criteria outlined on the research briefs. [O3]

Consolidate and apply

- The pupils could be set a challenge to **design** a new product that makes use of waves in a way they have investigated or researched over the course of the unit. The pupils should be grouped so they are working in teams of 6–8 and each pupil given a role in the team. Roles might include: project manager, researchers, sub-team manager, presenter, designer, advertising manager, etc. [O1 and O2]
- Alternatively, pupils could be asked to **write** all of the waves key words randomly scattered on a sheet of A3 plain paper. They should then **link** the words in as many ways as they can (linking them with lines) and **write** over the lines what the link between the words is. For example, the pupils could link 'pitch' and 'frequency' with a line, and over the line write 'the higher the frequency, the higher the pitch'. They should be sure to include the new learning from the lesson, therefore including applications and uses of waves. [O1]

Extend

- The pupils could be asked to **write** two exam-style questions and the corresponding mark schemes. They should **write** one question which only makes use of 1 or 2 mark questions and a second question which includes sub-questions of at least 4 marks. [O1]
- Alternatively, pupils could be asked to **create** a timeline (from 1917 to 2010) outlining the history of the laser. A link such as this could be used to supply the information. http://www.photonics.com/ Pupils could work in small groups and divide the timeline between them. [O2]

Plenary suggestions

Silent animation: Show pupils a short video clip without sound (perhaps a use of a laser) and ask them to say what they think is happening. They could either **suggest** the ideas or do a 'voice over' for it.

Hot seat: Ask each pupil to think up a question, using material from the topic. Select someone to be put in the hot seat, ask pupils to **ask** their question and say at the end whether the answer is correct or incorrect.

Waves: Lesson 2

Lesson overview

Learning objectives

- To describe wave motion
- To define wavelength and frequency
- To apply the relationship between wavelength, frequency and wave velocity

Learning outcomes

- To understand that waves have velocity, wavelength and frequency [O1]
- To use the equation $v = \lambda \times f$ to calculate wave velocity [O2]
- To rearrange the equation $v = \lambda \times f$ to calculate the wavelength or frequency of waves [O3]

Skills development

- To use an equation with three variables
- To manipulate an equation with three variables
- To use a variety of technical terms correctly

Maths focus

Use and rearrangement of an equation with three variables

Resources needed Worksheet 2.2a.1, 2.2a.2, 2.2a.3; Worksheet 2.2b.1, 2.2b.2, 2.2b.3; cathode ray oscilloscope, signal generator, loudspeaker

Digital resources Animation of cathode ray oscilloscope, signal generator and loudspeaker if equipment is not available

Key vocabulary frequency, wavelength, amplitude, time period, wave velocity, hertz

Teaching and learning

Engage

- Arrange the pupils around the edge of the classroom, facing inwards and ask them to start a Mexican wave. Allow the pupils to **watch** it as it propagates around the room. Be sure to emphasise the point that the pupils themselves are not moving around the edge of the room, but the energy is. [O1]

Challenge and develop

- Using a signal generator, a cathode ray oscilloscope and a loudspeaker, show the pupils an image of a sound wave on the oscilloscope screen. Use this to introduce the terms ‘amplitude’, ‘wavelength’, ‘frequency’ and ‘time period’. [O1] (If the equipment is not available, use a suitable animation instead).
- Change the nature of the wave on the screen and ask pupils to – using the key words of amplitude, wavelength and frequency – **describe** the new wave. [O1]
- Pupils should be issued with the Wave Features worksheet appropriate to their level:
  - Low demand: Worksheet 2.2a.1 [O1]
  - Standard demand: Worksheet 2.2a.2 [O1]
  - High demand: Worksheet 2.2a.3 [O1]

Explain

- Introduce the wave equation as a means of linking the wavelength and the frequency of a wave. Be sure to highlight the need for the pupils to be consistent with their units when they are using the wave equation. [O2]
- To get the idea across, ask pupils to **imagine** a stone thrown into a pond and the ripples moving outwards (or use a suitable video clip or animation). Suggest that the splash makes 3 ripples per second (i.e. the *frequency*) and the ripples are 6 cm apart (i.e. the *wavelength*). Pose the question 'how far will the first ripple travel in the first second (or 'each second')?'. Pupils should quickly **answer** with 18 cm, establishing the link summarised by the wave equation. [O2]

Consolidate and apply

- Issue the pupils with The Wave Equation worksheet that is appropriate to their level. [O2 and O3]
  - Low demand: Worksheet 2.2b.1 [O2]
  - Standard demand: Worksheet 2.2b.2 [O2]
  - High demand: Worksheet 2.2b.3 [O2 and O3]

Extend

Ask pupils able to progress further to:

- **Think** back to the Mexican wave set up at the start of the lesson. Ask the pupils, in no more than 30 words, to **explain** whether a Mexican wave is a real wave or not. [O1]

Plenary suggestions

- **Ideas hothouse:** Ask the pupils to work in pairs to **list** 3 points about what they know about waves from the lesson today. Then ask the pairs to join together into 4s and then 6-8s to **discuss** this further and to come up with an agreed list of points. Ask one person from each group to **report** back to the class.
- **Heads and tails:** Ask each pupil to write a question (probably related to the wave equation) on a coloured paper strip and then answer on another colour. In groups of 6-8, hand out the strips so that each pupil gets a question and an answer. One pupil **reads** out their question. The pupil with the right answer then **reads** it out, followed by their question, and so on.

Answers to Worksheets 2.2a.1–2.2a.3

1. 1 = wavelength; 2 = amplitude; 3 = peak; 4 = trough
2. (words in this order) height, amplitude, peak, trough, wavelength, metres, frequency, number, second, hertz

Answers to Worksheet 2.2b.1

1. 60 m/s; 2. 450 m/s; 3. 500 m/s; 4. 1250 m/s; 5. 500 m/s; 6. 15,000 m/s; 7. 0.6 m/s; 8. 12,000 m/s; 9. 8000 m/s; 10. 1800 m/s

Answers to Worksheet 2.2b.2

1. 60 m/s; 2. 450 m/s; 3. 500 m/s; 4. 1250 m/s; 5. 500 m/s; 6. 21.5 Hz; 7. 1.1 Hz; 8. 480 Hz 9. 0.1 Hz; 10. 4×10^{11} Hz

Answers to Worksheet 2.2b.3

1. 2.5 m/s; 2. 50 m/s; 3. 16,000 m/s; 4. 33Hz; 5. 0.8 Hz; 6. 300 Hz; 7. 6 m; 8. 0.42 m 9. 300 m; 10. 0.67 m

Waves: Lesson 3

Lesson overview

Learning objectives

- To apply the equations: $T = \frac{1}{f}$ and $v = f\lambda$
- Substitute numerical values into equations using appropriate units
- Change the subject of a equation

Learning outcomes

- To substitute values into equations
- To rearrange an equation to make another variable the subject
- To apply the equation $v = f\lambda$ to the electromagnetic spectrum

Maths focus

- To use the correct units for time period, frequency, wave speed and wavelength
- To rearrange equations with three variables

Resources needed Worksheet 2.3.1

Key vocabulary proportional, rearrange an equation, subject of an equation, substitute

Teaching and learning

Engage

- Show the pupils either an image or a short video clip of a pendulum clock and identify the time period of the clock as being the time taken to swing from one position and back to the same position. [O1]
- Ask pupils to explain the link between time period and frequency.

Challenge and develop

- Ask pupils to read spread topic 2.3 of the pupil book and answer questions 1–6.
- Remind pupils that they should do the same operation to both sides of an equation when rearranging it.
- Give pupils a couple of equations. Ask them to substitute a range of values into each equation. This can include equations they already know from the course.
- Give pupils a series of equations with their rearranged versions – some of them have been rearranged correctly, others incorrectly. Pupils identify which ones have been rearranged correctly, and rewrite the incorrect ones correctly.

Explain

- **Pair talk**: pupils explain how to change the subject of an equation.

Consolidate and apply

- Pupils answer the questions on Worksheet 2.3.1 on using of the wave equation.
- Standard and high demand: Pupils complete questions 7 and 8 from the pupil book.

Extend

Ask pupils able to progress further to:

- find out more about the speed of sound in different media.

Plenary suggestions

Ask pupils to produce a short set of instructions on how to rearrange an equation for a lower secondary pupil

Answers to Worksheet 2.3.1

1.

Region of spectrum	*v*, m/s	*f*, Hz	λ, m
Radio	3.0×10^{8}	1×10^{8}	3
Micro	3.0×10^{8}	3×10^{10}	1×10^{-2}
Infra-red	3.0×10^{8}	1×10^{13}	3×10^{-5}
Visible light	3.0×10^{8}	3×10^{14}	1×10^{-6}
Ultra violet	3.0×10^{8}	1×10^{16}	3×10^{-3}
X-ray	3.0×10^{8}	3×10^{17}	1×10^{-9}
Gamma	3.0×10^{8}	1×10^{20}	3×10^{-12}

2. 545.45 m
3. Red = 1×10^{14}; orange = 3×10^{14}; yellow = 3.3×10^{14}; green = 5×10^{14}; blue = 6×10^{14}; violet = 3×10^{15}

Waves: Lesson 4

Lesson overview

Learning objectives

- To compare the motion of transverse and longitudinal waves
- To explain why water waves are transverse waves
- To explain why sound waves are longitudinal waves

Learning outcomes

- To realise that waves can be transverse or longitudinal [O1]
- To give examples of transverse and longitudinal waves [O2]
- To explain the difference between transverse and longitudinal waves in terms of how they are produced [O3]

Skills development

- Correct use of key terms
- Plotting a bar chart of given data
- Identifying patterns in data

Maths focus

Plotting a bar chart from given data; identifying patterns in data from a bar chart

Resources needed Worksheet 2.4.1, 2.4.2, 2.4.3, Slinky, ripple tank (if available)

Digital resources PowerPoint 2.4.1

Key vocabulary transverse, longitudinal, medium, compression, rarefaction, oscillation, oscillate

Teaching and learning

Engage

- Watch the first 15 seconds of the Star Wars clip https://www.youtube.com/watch?v=xPZigWFyK2o and pose the question to the pupils: ‘what is wrong with this clip?’ (the space ship shouldn’t make a noise).

Challenge and develop

- Gather the pupils around one table and demonstrate a longitudinal wave using a slinky. Emphasise to the pupils where a rarefaction and a compression can be seen. Ask the pupils which way the waves are moving and what is happening to the individual coils in the slinky (they are oscillating backwards and forwards). Pose the question to the pupils ‘if the coils were not there, would the wave still move?’ (to introduce the idea that longitudinal waves need a medium through which to travel). [O1–O3]
- Now demonstrate a transverse wave and ask the pupils to **describe** the difference between this and the longitudinal wave they have just seen. [O1–O3]
- Demonstrate, through the use of a ripple tank, some water waves. (If a ripple tank is not available, use a suitable animation instead). Give the pupils time to **discuss** in pairs whether they think water waves are an example of longitudinal or transverse waves, giving a reason for their choice. A cork could be placed in the water to help the pupils decide. [O2]

Explain

- Return to the clip from the start of the lesson. Pair talk: With reference to the slinky demonstrations the pupils have seen, ask them to decide whether sound is an example of a transverse or a longitudinal wave. [O2]

Consolidate and apply

- Issue the pupils with the longitudinal waves worksheet appropriate for their ability. [O1, O3]
  - Low demand: worksheet 2.4.1 [O1, O3]
  - Standard demand: worksheet 2.4.2 [O1, O3]
  - High demand: worksheet 2.4.3 [O1, O3]

Extend

Ask students able to progress further to:

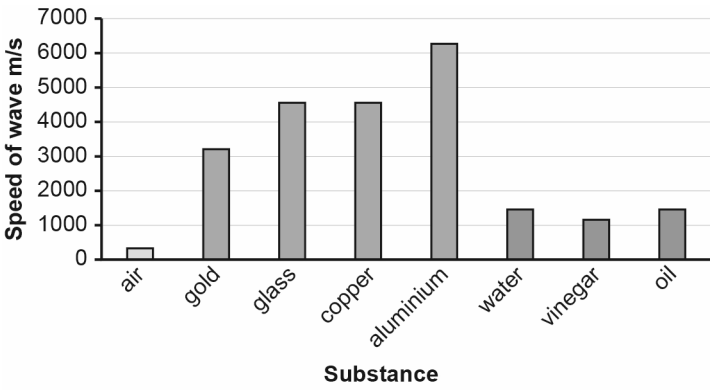
- Work in a pair to **discuss** how they could investigate the speed of longitudinal waves through different media using equipment available in the lab. They could be asked to **write** a plan for their investigation. [O3]

Plenary suggestions

- Show PowerPoint 2.4.1 which gives images of different examples of waves. Ask the students to **vote** on which type of wave they think is depicted by holding up a green card for longitudinal and a red card for transverse. [O1, O2]
- **What do I know?** Ask pupils to each **write** down one thing about the topic that they are sure of, one thing they are unsure of and one thing they need to know more about, being specific. Ask them to work in groups of 5-6 to agree on group lists, ask each to say what they have decided and **agree** as a class what they are confident about, what they are less sure of and what things they need to know more about. [O1–O3]
- **Freeze frame:** Ask pupils to **create** a freeze frame of either a transverse or a longitudinal wave. The other pupils are to **suggest** which wave it is and how they know. [O1, O3]

Answers to Worksheets 2.4.1 and 2.4.2

(worksheet 2.4.3 also has a bar for air at 40˚C)



Answers to Powerpoint 2.4.1

Slide 1 (radiowaves) – transverse; slide 2 (x-rays) – transverse; slide 3 (tsunami waves) – longitudinal; slide 4 (ultrasound) – longitudinal; slide 5 (ultraviolet) – transverse

Waves: Lesson 5

Lesson overview

Learning objectives

- To explain how the speed of sound in air can be measured
- To explain how the speed of water ripples can be measured
- To describe the use of echolocation

Learning outcomes

- To recognise that the speed of sound through solids and liquids is faster than in air [O1]
- To describe how to measure the speed of sound through air and the speed of water waves [O2]
- To know how to calculate the depth of water using the speed of sound through water in echo sounding and the time between signal and echo [O3]

Skills development

- Correct use of key terms

Resources needed Practical sheet 2.5.1, worksheet 2.5.1, 2.5.2, 2.5.3, technician sheet 2.5.1

Key vocabulary echo, echolocation

Teaching and learning

Engage

- Watch the clip at https://www.youtube.com/watch?v=KdaMiM-dJFc showing how to calculate the speed of sound in the air. Pose the question to the pupils 'how would the speed of sound differ had they conducted the experiment through a liquid or a solid?' (This is a direct link from the last lesson). [O1, O2]

Challenge and develop

- Ask the pupils to **investigate** the speed of water waves. Practical sheet 2.5.1 gives details of how to carry out this investigation. [O2]

Explain

- Introduce the concept of echolocation through a snowball to address the following question: 'having seen that waves reflect off a surface, how might this be useful for navigators on ships to calculate the depth of the sea?' (Individuals **consider** their answer briefly, then pairs **discuss** the question, then double up to fours and continue the process into groups of eight. This allows for comparison of ideas or to sort out the best answer. Finally, the whole class is drawn together and a spokesperson for each group of eight feeds back ideas). [O3]
- SONAR (SOund Navigation And Ranging) could also be introduced here.
- Show the BBC Ocean Giants: Voices of the Sea: Echolocation lifeline as an example of echolocation in action, where narwhals use sound to map air holes in ice. Link: http://www.bbc.co.uk/programmes/p00jz21r

Consolidate and apply

- Issue the pupils with the measuring wave speed worksheet appropriate for their ability. [O2, O3]
  - Low demand: worksheet 2.5.1[O2][O3]
  - Standard demand: worksheet 2.5.2 [O2, O3]

- High demand: worksheet 2.5.3 [O2, O3]

Extend

Ask pupils able to progress further to:

Pair talk: Give the pupils the following situation: despite hunting in complete darkness, bats are able to catch their prey effectively. **Explain** how. [O3]

Plenary suggestions

- **Ask me a question:** Ask pupils to **write** a question about measuring wave speeds and then a mark scheme for the answer. Encourage them to come up with ones worth more than one or two marks and try out their questions on one another. [O1–O3]
- Show a range of images of the use of echolocation in nature and ask the pupils to **explain** what is happening in the pictures. [O3]

Answers to Worksheets 2.5.1 and 2.5.2

1.
   a)
      i. 0.016 s
      ii. 0.33 s
   b)
      i. 900 m
      ii. 3000 m
2.
   a) light travels faster than sound
   b) 1800 m
   c) 1200 m closer (at 600 m)

Exam-style question:
Time to hit sea bed = 0.8/2 = 0.4 s [1]
1600 m/s × 0.4 s [1]
= 340 m [1]

Answers to Worksheet 2.5.3

1.
   a.
      i. 0.016 s;
      ii. 0.33 s
   b.
      i. 3000 m
      ii. 60 m
2.
   a. light travels faster than sound
   b. 5 s
   c. 900 m closer (at 600 m)

Exam-style question:
Time to hit sea bed = 0.8/2 = 0.4 s [1]
1600 m/s × 0.4 s [1]
= 340 m [1]

Waves: Lesson 6

Lesson overview

Learning objectives

- To describe reflection
- To describe refraction
- To explain total internal reflection

Learning outcomes

- To understand that waves may be reflected or refracted at a boundary, depending on the medium [O1]
- To draw a labelled ray diagram for reflection [O2]
- To draw ray diagrams to illustrate the three cases: refraction, critical angle and total internal reflection when a wave meets a boundary between two different media [O3]

Skills development

- To carry out fair and accurate investigations
- To analyse data collected from experiment
- To draw sensible conclusions from experimental data

Maths focus

Measuring angles using a protractor

Resources needed Practical sheets 2.6.1, 2.6.2 and 2.6.3; Practical 2.6.1 Periscope template; technicians sheets 2.6.1, 2.6.2 and 2.6.3; worksheets 2.6.1, 2.6.2 and 2.6.3

Key vocabulary reflection, refraction, critical angle, total internal reflection

Teaching and learning

Engage

- **Pair talk:** Show the pupils a picture of a fibre optic Christmas tree and ask the pupils to **describe** what they can see in the picture and ask them why the tree is only lit up at the ends of the cables, despite light only being able to travel in straight lines (i.e. ask them to think about what is actually happening to make the tree work). [O1]
- **Pair talk:** Alternatively, show the pupils a picture of a four-eyed fish and ask them to **think** about why the fish has evolved in this way (note: the fish does not actually have 4 eyes, but two eyes, each divided into two parts with lenses of different thickness at the top and bottom). You could give the students the clue that these fish float at the water surface. [O1]

Challenge and develop

- The pupils could be split into three groups to **complete** a circus of activities (detailed on practical sheets 2.6.1 – 2.6.3). Ideally, they should be ability-based, with group 1 as 'low demand', group 2 as 'standard demand' and group 3 as 'high demand'. Group 1 should be asked to work on reflection (practical sheet 2.6.1), group 2 on refraction (practical sheet 2.6.2) and group 3 on critical angle and total internal reflection. [O1–O3]
  - Practical 2.6.1 – making a periscope [O1]
  - Practical 2.6.2 – coin in mug followed by rectangular glass block to explain [O1]
  - Practical 2.6.3 – semi-circular blocks – three situations: below critical angle; at critical angle; above critical angle, leading on to s-shaped Perspex shape – can they shine a ray of light in and get it to emerge from the other end? [O3]

Explain

- Following the practical element to their task in the circus, the pupils should be asked to **complete** the follow-up questions related to their task which are outlined on the respective practical sheets. [O1–O3]

- The pupils could also be asked to **research** an everyday use for the phenomena they have just investigated (reflection, refraction or total internal reflection). [O1]

Consolidate and apply

- The pupils should then be regrouped in such a way as to ensure that there are pupils from groups 1, 2 and 3 working together to share their findings from the circus of activities. Pupils should be given 5 minutes each to **present** their experiment to the rest of the group.
- Pupils should then return to the 'expert' group they completed the practical work in to **complete** the reflection and refraction worksheet appropriate to their level which will summarise the learning points from each of the three tasks [O1–O3]
  - Low demand (reflection group): worksheet 2.6.1
  - Standard demand (refraction group): worksheet 2.6.2
  - High demand (total internal reflection group): worksheet 2.6.3

Extend

Ask students able to progress further to:

- Return to the picture(s) from the start of the lesson. Can they **explain** what is happening in each of the pictures using the key words they have learned about in the lesson? [O1]
- Alternatively, the pupils could be asked to use ideas about reflection to **explain** how concave mirrors collect light and how convex mirrors spread light out and **suggest** a use for each type of curved mirror. [O1]
- As a way of further investigating refraction, the pupils could be asked to **research** the cause of mirages on road surfaces in summer time. [O1]

Plenary suggestions

- **Learning triangle:** At the end of the lesson ask the pupils to **draw** a large triangle with a smaller inverted triangle that just fits inside (so they have four triangles). In the outer three, ask them to think back over the lesson and **identify** (and write in the respective triangles):
  - something they have seen
  - something they have done
  - something they have discussed

  then add to the central triangle something they have learned.
- **The big ideas:** Ask the pupils to **write** down three ideas they learnt during the lesson. Then ask them to **share** their facts in groups and to **compile** a master list of facts, with the most important at the top. Ask for ideas to be shared and find out which other group(s) agreed with their suggestions.

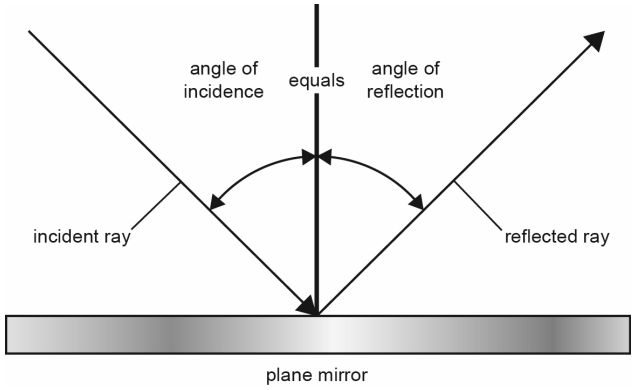
Answers to Worksheets 2.6.1 and 2.6.2

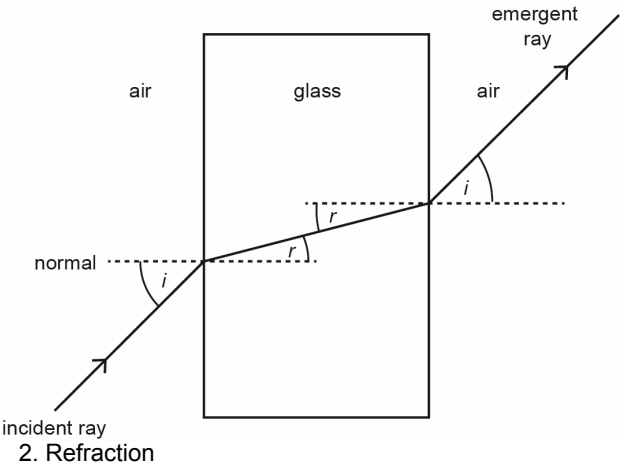
Worksheets 6.1.1 and Worksheet 6.1.2

1. Laws of relfection: incidence, the same, angle
2. Refraction: glass, towards, glass, air, away from, denser, travelled slower, travelled faster
3. Total internal reflection: used in medicine/ communication

Answers to Worksheet 2.6.3

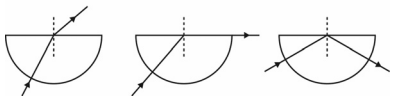
1. Reflection





2. Refraction

3. Total internal reflection



Waves: Lesson 7

Lesson overview

Learning objectives

- To make and record observations of waves
- To use models to investigate physical phenomena
- To draw conclusions from experimental results

Learning outcomes

- To review the key words from the Waves chapter and match them with their definitions [O1]
- To investigate how light reflects off different surfaces [O2]
- To use experimental results to draw conclusions about the behaviour of light [O3]

Skills development

- To carry out fair and accurate investigations
- To analyse data collected from experiments
- To draw sensible conclusions from experimental data

Maths focus

Measuring angles

Resources Worksheet 2.7.1, worksheet 2.7.2; practical 2.7.1, practical 2.7.2, practical 2.7.3, practical 2.7.4; technician notes 2.7.1

Key vocabulary reflection, refraction, absorption, specular, diffuse, ray, normal, angle

Teaching and learning

Engage

- Card sort (worksheet 2.7.1): pupils review the key words they have learnt during the topic (and the key words that will be used in this lesson) by matching each key word with its definition. [O1]
- Alternatively, the pupils should **complete** the crossword (worksheet 2.7.2) which recaps the key words from the waves section. [O1]

Challenge and develop

- Show the pupils images of children's toys which rely on the principles of the behaviour of light waves, such as a kaleidoscope, a pair of diffraction glasses, bubble mirror walls and a simple prism. Ask the pupils to **offer** an explanation for how these toys work. Encourage the use of the key words from the activity at the start of the lesson. [O1]

Explain

- The pupils should be split into four different groups and each group should be given a practical situation to investigate. [O2, O3]
  - Practical 2.7.1 (low demand) – mirrors at different angles to produce multiple images
  - Practical 2.7.2 (standard demand) – investigating reflection and absorption of light shone on different coloured surfaces
  - Practical 2.7.3 (standard demand) - investigating different surfaces for reflection, refraction and absorption
  - Practical 2.7.4 (high demand) – investigating diffuse and specular reflection

Consolidate and apply

- The pupils should be regrouped so that there is someone from each practical task in the group. They should be given two minutes each to **report** on the aim of their investigation and their findings. [O2, O3]
- Following the feedback, the group should **suggest** an everyday application of each phenomenon that has been investigated. [O2, O3]

Extend

- Pupils could be asked to **design** a new toy for children that relies on at least one of the phenomena discovered during the investigations in the lesson. [O2, O3]

Plenary suggestions

Heads and tails: Ask each pupil to **write** a question about something from the topic on a coloured strip of paper and the answer on another colour. In groups of 6-8, hand out the strips so that each pupil gets a question and an answer. One pupil reads out their question. The pupil with the right answer then reads it out, followed by their question.

Ask me a question: Ask pupils to **write** a question about something from the topic and then a mark scheme for the answer. Encourage them to come up with questions worth more than 1 or 2 marks and to try out their questions on one another.

Answers to Worksheet 2.7.2

Solutions to the crossword clues:

Across

4. ABSORPTION
5. SPECULAR REFLECTION
6. LIGHT RAY
7. DIFFUSE REFLECTION
8. REFRACTION

Down

1. REFLECTION
2. ANGLE OF REFLECTION
3. NORMAL
4. ANGLE OF REFRACTION

Waves: Lesson 8

Lesson overview

Learning objectives

- To describe how we hear sound and state the range of frequencies we can hear
- To explain that sound travels faster in a denser medium
- To explain about reflection, absorption and transmission of sound

Learning outcomes

- To recognise that the speed of sound through liquids and solids is faster than in air [O1]
- To list the upper and lower limits of human hearing [O2]
- To apply the principle of conservation of energy to the reflection, transmission and absorption of waves [O3]

Skills development

- Taking a set of data and producing a chart
- Drawing conclusions from a chart
- Planning a valid investigation

Maths focus

Drawing graphs (scales on axes)

Resources needed Worksheet 2.8.1, worksheet 2.8.2, worksheet 2.8.3, image of the ear (unlabelled)

Key vocabulary frequency, hertz, absorption, transmission, reflection, state of matter

Teaching and learning

Engage

- The Mosquito Device – Show the pupils a news article about the deployment of the Mosquito Device to deter youngsters from loitering. **Discuss** the article, with the discussion including why the device is used, how it works (at the basic level) and the social implications of using such a device. The discussion could end with the pupils voting on whether they agree with its use or not, giving a reason for their choice. (For example, search for 'Daily Mail mosquito alarm'). [O2]

Challenge and develop

- **Sound circus**: There are three tasks for the pupils to **complete** and these should be done as a circus of tasks, where the pupils should be given a set time to work on one task before moving on to the next. The tasks address: species ranges of hearing, labelling the structure and function of the ear and a planning activity which addresses reflection, transmission and absorption of sound waves. [O1–O3]
  - Worksheet 2.8.1: Data Task – Ranges of Hearing. Pupils are given a set of data and are asked to **plot** the data on a suitable chart to show the hearing ranges of different species. [O2]
  - Worksheet 2.8.2: The Structure of the Ear. Pupils work in groups of four. An A3 image of the structure of the ear (unlabelled) is taped to the back of the classroom door. Each pupil in the group is given 30 seconds in turn to visit the picture of the structure of the ear and a further 30 seconds back with their group to **draw** what they can remember. They are allowed to **communicate** with each other between visits to the picture to enable them to **reproduce** the whole image as a team. They should then be given access to suitable reference material to label the different parts of the ear and the function that each part carries out. [O1]
  - Worksheet 2.8.3: Travelling Sound. The pupils are asked to **design** an investigation to test whether all materials reflect, absorb and transmit sound by the same amount, or whether some are better reflectors,

absorbers and transmitters. An extension to this would be to **investigate** whether the surface of each material makes a difference to the amount of sound that is reflected. [O1, O3]

Explain

- **Pair Talk:** The pupils should be given the opportunity to **discuss** the three tasks they have completed and to list anything that surprised them. Each pupil should then be given a sticky note and they should **write** down one thing that surprised them and two things that they learned. These sticky notes should be stuck onto the board and discussed as a group. [O1–O3]

Consolidate and apply

- In listening triads (where pupils work in groups of three and each pupil takes on the role of either talker, questioner or recorder. The talker explains their ideas. The questioner prompts and seeks clarification. The recorder makes notes and gives a report at the end of the conversation) the pupils should **explain** how knowledge of how sound travels in different materials is important when designing a multiplex cinema. [O1, O3]
- Alternatively, the pupils could be given an outline image of a multiplex cinema and asked to **label** the different materials that might be used in the construction of the site, giving reasons for their choices. [O1, O3]

Extend

Ask students able to progress further to:

- **Research** reverberation time in concert halls and explain their findings to the class or a small group. [O3]

Plenary suggestions

- **The big ideas** Ask pupils to **write** down three ideas they learnt during the topic. Then ask them to share their facts in groups and to compile a master list of facts, with the most important fact at the top. Ask for ideas to be shared and find out which other group(s) agreed.
- **Hot seat** Ask each pupil to think of a question, using material from the topic. Select someone to put in the hot seat, ask pupils to ask their question and say at the end whether the answer is correct or incorrect.

Answers to Worksheet 2.8.1

1. Bat, mouse, dolphin
2. Bat, rabbit, cat, dog, mouse, dolphin
3. Any frequency above 20,000 Hz and below 46,000 Hz

Waves: Lesson 9

Lesson overview

Learning objectives

- To list the advantages of using ultrasound
- To describe how ultrasound is used for body scans
- To explain how ultrasound is reflected at each surface in a body scan when there is a difference in density between one organ and another

Learning outcomes

- To define the term ultrasound [O1]
- To describe how ultrasound is used for body scans [O2]
- To list some advantages of using ultrasound to examine the human body [O3]

Resources needed signal generator, cathode ray oscilloscope, loudspeaker, worksheet 2.9.1, worksheet 2.9.2, worksheet 2.9.3

Key vocabulary reflection, ultrasound, hertz, transmission, absorption, density, medium

Teaching and learning

Engage

- Ask the pupils to **discuss** where they have come across the term 'ultrasound' before asking them to feedback and sharing class ideas. Now pose the question 'what is ultrasound?' and take suggested answers. [O1]
- Using a signal generator, cathode ray oscilloscope and a loudspeaker, demonstrate ultrasound to the pupils. If a signal generator or CRO is not available, use a suitable animation instead. [O1]

Challenge and develop

- Show the pupils a range of images of ultrasound scans being used in the following situations and ask the pupils what they think is happening in each picture and if they can **suggest** how they might be working:
  - Foetal ultrasound scans (to view the foetus in pregnancy)
  - Opthalmic ultrasound scans (to view the structures in the eye)
  - Echocardiograms (to view the heart)
  - Abdominal ultrasound scans (to view the tissues and organs)
  - Bone sonometry (to investigate bone strength) [O2]

Explain

- Using either the text from the Student Book ('How a body scan works' section) or a similar explanation from a different research source, the pupils should **design** a story board outlining how an ultrasound scan works. [O2, O3]
- Alternatively, the pupils could be asked to **design** a leaflet (perhaps for the NHS) to be given to pregnant women which outlines what they should expect from their ultrasound scan, how the scan works and what the advantages of using ultrasound to scan the body (and the foetus) are. [O2, O3]

Consolidate and apply

- The pupils should be issued with the exploring ultrasound worksheet appropriate to their level. [O1–O3]
- Low demand: worksheet 2.9.1. A postcard template could be supplied to structure this task further.
- Standard demand: worksheet 2.9.2. An alternative to this could be for these pupils to make a 2 minute film to be shown in the waiting room of the hospital for pregnant women waiting to have their foetal ultrasound scan. Their film should include what to expect from the scan, how it works and why it is safe.
- High demand: worksheet 2.9.3.

Extend

- Ask the pupils to **suggest** and then **research** what the jelly which is applied to the abdomen before a foetal ultrasound scan is for. [O2]

Plenary suggestions

Ask me a question Ask the pupils to **write** a question about something from the topic and then a mark scheme for the answer. Encourage them to come up with questions worth more than 1 or 2 marks and to try out their questions on one another.

Heads and tails Ask each pupil to **write** a question about something from the topic on a coloured paper strip and the answer on another colour. In groups of 6–8, hand out the strips so that each pupil gets a question and an answer. One pupil reads out their question. The pupil with the right answer then reads it out, followed by their question, and so on.

Waves: Lesson 10

Lesson overview

Learning objectives

- To describe the use of ultrasound vibrations to clean a variety of objects
- To describe the use of ultrasound vibrations in medicine
- To explain why ultrasound can be used for these tasks

Learning outcomes

- To list some medical and non-medical uses of ultrasound [O1]
- To list some advantages of using ultrasound to examine the human body [O2]
- To consider why ultrasound can be transmitted as a beam [O3]

Skills development

- To research a specific concept
- To draw conclusions from research
- To share ideas with others

Resources needed worksheet 2.10.1, worksheet 2.10.2, worksheet 2.10.3, access to online research sources

Key vocabulary ultrasound, transmission, absorption, reflection, frequency

Teaching and learning

Engage

- Show the pupils a series of images of ultrasound being used to:
  - find cracks in aircraft
  - clean jewellery
  - measure the thickness of objects
  - clean teeth
  - clean medical instruments
  - destroy kidney stones. [O1]
- Ask the pupils to **discuss** in pairs what they think is happening in each picture. Tell the pupils that ultrasound is being used in each picture, before asking them to **suggest** how it is being used in each case. [O1]
- Ask the pupils to **feedback** to the class to develop these explanations. [O1]

Challenge and develop

- **Pair talk:** Give the pupils access to textbooks and/or online material and ask them to **create** a list of three advantages of using ultrasound for the applications shown the in pictures from the first activity. [O2]
- **Pairs to fours:** The pupils should **share** their findings with another pair and the group of four should be tasked with coming up with a final list of three advantages. [O2]

Explain

- **Jigsaw:** The pupils should be split into four groups, with pupils given a number between 1 and 4. All pupils given number one should join as a group, all number two's as another group and so on. The pupils should be given access to online research sources and each group will **research** one application of ultrasound. Once they have gathered information, regroup the pupils in groups of 4 so that each new group contains one pupil who was given number one, one pupil who was given number two, and so on.
- Groups should research the following applications:
  - Group 1: cleaning building, spectacles and jewellery
  - Group 2: breaking down kidney stones
  - Group 3: treating cataracts
  - Group 4: finding cracks in aircraft.
- The pupils should then be given 2 minutes to **present** their findings to the rest of the group. [O1, O2]

Consolidate and apply

- The pupils should be issued with the using ultrasound worksheet appropriate to their level [O1, O2]
  - Low demand: worksheet 2.10.1
  - Standard demand: worksheet 2.10.2
  - High demand: worksheet 2.10.3

Extend

- Using ideas about speed of waves in air, frequency and wavelength, ask the pupils to **explain** why ultrasound is able to be transmitted as a beam. [O3]

Plenary suggestions

Learning triangle: Ask the pupils to draw a large triangle with a smaller inverted triangle that just fits inside it (so they have four triangles). In the outer three, ask them to think back over the lesson and **identify** and write in the respective triangles:

- something they have seen
- something they have done
- something they have discussed.

Then add to the central triangle something they have learned.

What do I know? Ask pupils to each write down one thing about the topic they are sure of, one thing they are unsure of and one thing they need to know more about, being specific. Ask them to work in groups of 5 – 6 to agree on group lists, ask each group to say what they decided and agree as a class about what they are confident about, what they are less sure of and what things they want to know more about.

Answers to Worksheets 2.10.1 and 2.10.2

1. **Jewellery:** (words in this order): energy, frequency, bubbles, bubbles, dislodge
2. **Kidney stones:** (words in this order): energy, probe, vibrate, stones, break
3. **Cataracts:** (words in this order): cornea, probe, ultrasound, eye, lens, replaced
4. **Aircraft:** (words in this order): waves, cracks, scanner, path, reflected, monitor

Waves: Lesson 11

Lesson overview

Learning objectives

- To describe how earthquakes are detected
- To describe the types of waves that earthquakes produce
- To explain how the properties of earthquake waves allow us to investigate the inside of the Earth

Learning outcomes

- To know how earthquakes can be detected [O1]
- To use the terms 'focus' and 'epicentre' correctly [O2]
- To use the properties of S-waves and P-waves to deduce useful information about the structure of the Earth [O3]

Skills development

- To consider a range of evidence
- To draw conclusions from evidence
- To communicate ideas clearly

Resources needed Worksheet 2.11.1, worksheet 2.11.2, worksheet 2.11.3

Key vocabulary earthquakes, seismic waves, L-waves, S-waves, P-waves, focus, epicentre, seismometer

Teaching and learning

Engage

- Show the pupils a clip of CCTV footage from the Nepal earthquake in April 2015. Following the clip, locate Nepal on a world map that has the tectonic plate boundaries marked. [O1]

Challenge and develop

- Either provide the pupils with a list of recent earthquakes and ask them to **plot** these on a map template or show an image of a world map with earthquake sites marked.
- **Pair talk:** What patterns can be seen in the picture? What conclusions can be drawn from the patterns that have been identified? Pairs to fours: each pair should join up with another pair to **share** ideas and then **feedback** to the class. [O1]

Explain

- Ask the class to **discuss**: How is the Earth's movement monitored? How are earthquakes detected? A seismometer in Nepal would detect more waves than one placed on the opposite side of the Earth (in Chile) – are all waves the same? How do we know? [O1]
- Remind the pupils of the difference between longitudinal and transverse waves (perhaps by modelling using a slinky) and ask the pupils to **give** an example of each type of wave. Remind the pupils of the materials that transverse and longitudinal waves will pass through.
- Refer to a picture of P- and S-waves transmitted through the Earth – what can be deduced about the nature of each type of wave and therefore about the structure of the Earth? [O3]

Consolidate and apply

- Using the report template appropriate to their level, the pupils should **write** a report for a journal on the earthquake in Nepal. The report should include: the cause of the earthquake, how the earthquake can be detected, different types of wave that the earthquake produced, what can be deduced about the nature of the structure of the Earth from looking at the patterns on seismometers. [O2, O3]

- Low demand: worksheet 2.11.1
- Standard demand: worksheet 2.11.2
- High demand: worksheet 2.11.3

- Alternatively, the class could be asked to **produce** a news report for the 6 o'clock news. The class should be split into groups, where pupils act as either scientists, news reporters (to screen), journalists (who carry out interviews), local residents and politicians. The pupils could write a script and then film their report. [O2][O3]

Extend

- The pupils could be asked to **research** the aftershocks of a particular earthquake and then **present** their findings to the rest of the class.
- Alternatively, pupils could be asked to **investigate** the time difference between the detection of a P- and an S-wave and therefore **decide** the position of an earthquake, given the speeds of both types of wave.

Plenary suggestions

The big ideas: Ask pupils to **write** down three ideas they learnt during the topic. Then ask them to **share** their facts in groups and to **compile** a master list of facts, with the most important at the top. Ask for ideas to be shared and find out which other group(s) agreed.

Ideas hothouse: Ask pupils to work in pairs to **list** points about what they know about a particular idea. Then ask the pairs to join together into 4s and then 6-8s to **discuss** this further and to come up with an agreed list of points. Ask one person from each group to **report** back to the class.

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