# *PLANNING SUPPORT BOOKLET*

**J259, J260**

**For first teaching in 2016**

This support material booklet is designed to accompany the OCR GCSE (9–1) specification in Physics B and Combined Science B (Twenty First Century Science).

***DISCLAIMER***

This resource was designed using the most up to date information from the specification at the time it was published. Specifications are updated over time, which means there may be contradictions between the resource and the specification, therefore please use the information on the latest specification at all times.If you do notice a discrepancy please contact us on the following email address: [resources.feedback@ocr.org.uk](mailto:resources.feedback@ocr.org.uk)

## Introduction

This support material is designed to accompany the OCR GCSE (9-1) specification in Physics B (Twenty First Century) for teaching from September 2016.

The Planning Guidance table on the following pages sets out *suggested* teaching times for the topics within the specification. Note that we always recommend that individual centres plan their schemes of work according to their individual needs. Actual teaching times for topics will depend on the amount of practical work done within each topic and the emphasis placed on development of practical skills in various areas, as well as use of contexts, case studies and other work to support depth of understanding and application of knowledge and understanding. It will also depend on the level of prior knowledge and understanding that learners bring to the course.

The table follows the order of the topics in the specification. It is not implied that centres teach the specification topics in the order shown, centres are free to teach the specification in the order that suites them.

## Delivery guides

The column ‘Delivery guides’ refers to individual teacher guides available from the GCSE Physics B qualification page.

These Delivery guides provide further guidance and suggestions for teaching of individual topics, including links to a range of activities that may be used and guidance on resolving common misconceptions.

## Ideas about Science (P7) and Practical Work (P8)

Ideas about Science (P7) and Practical Skills (P8) are not explicitly reference in the high level planning table below, as these ideas and skills are expected to be developed in the context of Topics P1-P6. Links to P7 learning outcomes and suggested practical activities are included in the outline scheme of work. Indications of where PAG activities can be carried out should not be seen as an exhaustive list.

| **Topic** | | **Teaching hours**  separate / combined | **Delivery Guides** | **PAG opportunities** | |
| --- | --- | --- | --- | --- | --- |
| **Chapter 1: Radiation and waves** | | | | | |
| 1.1 What are the risks and benefits of using radiation | 5 / 5 hours | | Radiation and waves – delivery guide |  |
| 1.2 What is climate change and what is the evidence for it? | 3 / 3 hours | | Radiation and waves – delivery guide |  |
| 1.3 How do waves behave? | 7 / 7 hours | | Radiation and waves – delivery guide | PAG4: measure the speed, frequency and wavelength of a wave  PAG8: Investigate the reflection and refraction |
| 1.4 What happens when light and sound meet different materials? (separate science only) | 7 / 0 hours | | Radiation and waves – delivery guide |  |
| **Total for chapter 1 = 22 / 15 hours** | | | | |
| **Chapter 2: Sustainable energy** | | | | |
| 2.1 How much energy do we use? | 4 / 4 hours | | Sustainable energy – delivery guide |  |
| 2.2 How can electricity be generated? | 5 / 5 hours | | Sustainable energy – delivery guide |  |
| **Total for chapter 2 = 9 / 9 hours** | | | | |
| **Chapter 3 Electric circuits** | | | | |
| 3.1 What is electric charge (separate science only) | 2 / 0 hours | | Electric circuits – delivery guide |  |
| 3.2 What determines the current in an electric circuit? | 4 / 4 hours | | Electric circuits – delivery guide | PAG6: Investigate the I-V characteristics of circuit elements |
| 3.3 How do series and parallel circuits work? | 5 / 5 hours | | Electric circuits – delivery guide | PAG7: Investigate the brightness of bulbs in series and parallel |
| 3.4 What determines the rate of energy transfer in a circuit? | 4 / 4 hours | | Electric circuits – delivery guide |  |
| 3.5 What are magnetic fields? | 4 / 3 hours | | Electric circuits – delivery guide |  |
| 3.6 How do electric motors work? | 3 / 3 hours | | Electric circuits – delivery guide |  |
| 3.7 What is the process inside an electric generator? (separate science only) | 4 / 0 hours | | Electric circuits – delivery guide |  |
| **Total for chapter 3 = 26 / 19 hours** | | | | |
| **Chapter 4 Explaining motion** | | | | |
| 4.1 What are forces? | 4 / 4 hours | | Explaining motion – delivery guide |  |
| 4.2 How can we describe motion? | 7 / 7 hours | | Explaining motion – delivery guide | PAG3: Investigate acceleration of a trolley down a ramp |
| 4.3 What is the connection between force and motion? | 12 / 9 hours | | Explaining motion – delivery guide |  |
| 4.4 How can we describe motion in terms of energy transfer? | 5 / 5 hours | | Explaining motion – delivery guide |  |
| **Total for chapter 4 = 28 / 25 hours** | | | | |
| **Chapter 5 Radioactive materials** | | | | |
| 5.1 What is radioactivity? | 6 / 6 hours | | Radioactive materials – delivery guide |  |
| 5.2 How can radioactive materials be used safely? | 3 / 3 hours | | Radioactive materials – delivery guide |  |
| 5.3 How can radioactive materials be used to provide energy? (separate science only) | 4 / 0 hours | | Radioactive materials – delivery guide |  |
| **Total for chapter 5 = 13 / 9 hours** | | | | |
| **Chapter 6 Matter – models and explanations** | | | | |
| 6.1 How does energy transform matter? | 5 / 5 hours | | Matter – delivery guide | PAG1: Determine the densities of a variety of objects both solid and liquid  PAG5: Determine the specific heat capacity of a metal |
| 6.2 How does the particle model explain the effects of heating? | 2 / 2 hours | | Matter – delivery guide |  |
| 6.3 How does the particle model relate to material under stress? | 4 / 4 hours | | Matter – delivery guide | PAG2: Investigate the effect of forces on springs |
| 6.4 How does the particle model relate to pressure in fluids? (separate science only) | 5 / 0 hours | | Matter – delivery guide |  |
| 6.5 How can scientific models help us understand the Big Bang? (separate science only) | 6 / 0 hours | | Matter – delivery guide |  |
| **Total for chapter 6 = 22 / 11 hours** | | | | |
| **Total teaching hours = 120 / 88 hours** | | | | |

# Outline Scheme of Work: P1 – Radiation and Waves

## Total suggested teaching time – 22 hours

|  |  |
| --- | --- |
| **Additional online learning opportunities**  As a response to the Covid-19 outbreak, additional online learning opportunities were identified for each topic in June 2020. | |
| **Statement** | **Teaching activities** |
| P1.3.3 | Cambridge International Resource Plus [video](https://ocr.org.uk/rpgphys10) covering transverse and longitudinal waves, frequency, amplitude, reflection, refraction and diffraction which can be used as flipped learning. |
| P1.3.1, P1.3.5 | Cambridge International example candidate response [resource](https://ocr.org.uk/rpgphys11) - Paper 4 Question 6 can be used as homework. |
| P1.3.6 | [Worksheet](https://www.tes.com/teaching-resource/gcse-physics-wave-speed-equation-practice-wavespeed-equals-frequency-x-wavelength-11442908) on wave equation and solutions can be used for homework. |
| P1.3.8 | Cambridge International [Video](https://ocr.org.uk/rpgphys12) showing reflection, refraction and TIR can be used as flipped learning. |
| P1.3.8 | Cambridge International example candidate response [resource](https://ocr.org.uk/rpgphys13). Paper 3 Q8 can be used as homework on reflection and refraction (lesson 5). |
| P1.4.1, P1.4.2, P1.4.3 | Footprints Science [quiz](https://www.footprints-science.co.uk/index.php?quiz=Lenses_and_refraction) on lenses can be used as a homework. |
| P1.4.1, P1.4.2, P1.4.3 | Paper 3 (Light) Q8 on reflection, either from the topic questions or exemplars, from this Cambridge International [resource](https://ocr.org.uk/rpgphys13) can be used as a homework. |
| P1.4.5 | Short [video](https://www.youtube.com/watch?v=iZCWCZ0alkY) on dispersion by prism, can be used as flipped learning. |
| P1.4.7 | Cambridge International [video](https://ocr.org.uk/rpgphys14) on sound waves can be used as flipped learning for lesson 6. |
| P1.4.8 | Ultrasound, seismic and sonar activities suitable for home learning:  <https://www.stem.org.uk/elibrary/resource/31828>  <https://spark.iop.org/videos-age-14-16-ks4-support-remote-teaching-and-learning-light-sound-and-waves>  <https://www.tes.com/teaching-resource/ultrasound-lesson-6318455> |

### P1.1 What are the risks and benefits of using radiations? (5 hours)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * know the similarities and differences between light waves and waves in matter * have observed waves on water, spring and string | |
| Links to Mathematical Skills  * NA | Links to Mathematical Skills  * NA |

# Overview of P1.1 What are the risks and benefits of using radiation?

| Lesson | Statements | Teaching activities | Notes |
| --- | --- | --- | --- |
| 1 (1hr for separate and combined) | P1.1.1 describe the main groupings of the electromagnetic spectrum – radio, microwave, infrared, visible (red to violet), ultraviolet, X-rays and gamma rays, that these range from long to short wavelengths, from low to high frequencies, and from low to high energies  P1.1.2 recall that our eyes can only detect a very limited range of frequencies in the electromagnetic spectrum | **Engage:** Electromagnetic spectrum [song](https://www.youtube.com/watch?v=bjOGNVH3D4Y)  **Explore**: [Topic exploration](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf) pack Activity 1 –Music Analogy for EM Spectrum activity  **Explain:** Worksheet to label the EM spectrum, pupils need to label the areas of the EM spectrum, add an image of what uses this and give a brief description.  Use EM waves – [Information sheet](https://www.ocr.org.uk/Images/222418-em-waves-information-sheet-topic-exploration-pack.doc) – Topic exploration pack  **Extend:** [Activity 1](https://coolcosmos.ipac.caltech.edu/page/what_is_infrared) from Radiation and waves delivery guide:  An outdoor version of Herschel’s experiment showing the existence of the infrared part of the spectrum of sunlight.  **Evaluate:** Radiation and waves [learner resource 1](https://www.ocr.org.uk/Images/268971-radiation-and-waves-learner-resource.doc): Create a mnemonic for the names of the regions of the EM spectrum. | Link to Topic exploration pack EM waves:  <http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf>  Link to Delivery guide Radiation and Waves:  <https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf>  Radiation and waves: Learner Resource:  <https://www.ocr.org.uk/Images/268971-radiation-and-waves-learner-resource.doc>  EM waves – information sheet – topic exploration pack  <https://www.ocr.org.uk/Images/222418-em-waves-information-sheet-topic-exploration-pack.doc> |
| 2(1hr for separate and combined) | P1.1.3 recall that all electromagnetic radiation is transmitted through space with the same very high (but finite) speed  P1.1.4 explain, with examples, that electromagnetic radiation transfers energy from source to absorber  P1.1.5 recall that different substances may absorb, transmit, or reflect electromagnetic radiation in ways that depend on wavelength | **Engage:** A [video](https://www.youtube.com/watch?v=OzFU6XvzzgA) summarising the electromagnetic spectrum with a brief guide to the characteristics of each part.  **Explore:** Activity 2 – [Transmission of EM Waves](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf)  **Explain:** Discuss results seen with class, make sure pupils have taken appropriate notes.  **Extend:** An excellent stretch and challenge activity for the interested learner would be to fully research and investigate the scientific theory to explain how the radiometer works. Playing devil’s advocate to oppose whatever idea the learner concludes will really stretch their understanding and ability to form evidence based conclusions. The task is particularly useful to illustrate the idea of discussion and debate within the scientific community, as there is such a wide range of material and opinions on the web.  **Evaluate:** Question from [sample assessment material](http://www.ocr.org.uk/Images/234632-unit-j259-01-breadth-in-physics-foundation-tier-sample-assessment-material.pdf) Foundation breadth in physics paper, J259/01: Q4aii, Q4b | Link to Topic exploration pack [EM waves](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf)  Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](http://www.ocr.org.uk/Images/234632-unit-j259-01-breadth-in-physics-foundation-tier-sample-assessment-material.pdf) |
| 3 (1hr for separate and combined) | P1.1.6 recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation, and that atoms can become ions by loss of outer electrons  P1.1.7 recall that changes in molecules, atoms and nuclei can generate and absorb radiations over a wide frequency range, including:  a) gamma rays are emitted from the nuclei of atoms  b) X-rays, ultraviolet and visible light are generated when electrons in atoms lose energy  c) high energy ultraviolet, gamma rays and X-rays have enough energy to cause ionisation when absorbed by some atoms  d) ultraviolet is absorbed by oxygen to produce ozone, which also absorbs ultraviolet, protecting life on Earth  e) infrared is emitted and absorbed by molecules | **Engage:** Thermal fart – a [short video](https://www.youtube.com/watch?v=md-cv2hyc8w) showing a fart as seen through a thermal imaging (infrared) camera. Short, simple, comic relief.  **Explore:** [Topic exploration pack Activity 3](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf) –EM Circus Activities  **Explain:** Pupils all complete [worksheet](https://www.ocr.org.uk/Images/222437-em-waves-learner-activity-topic-exploration-pack.doc) relating to the above circus  Learners should discuss with other members of the class if they have any blanks and try to find the answers. Teacher should then get feedback from learners regarding their answers.  **Extend:** A [video](https://www.youtube.com/watch?v=5kEzooS7bKU) containing some additional information about ultraviolet light. This contains a cursory account of fluorescence, as well as a fairly standard ‘educational’-style presentation of a digest of interesting aspects of ultraviolet radiation.  **Evaluate:**  Matching activity where learners match the type of radiation to the description | Link to Topic exploration pack [EM waves](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf)  Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf) |
| 4 and 5 (2hr for separate and combined) | P1.1.8 describe how ultra-violet radiation, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues  P1.1.9 give examples of some practical uses of electromagnetic radiation in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions of the spectrum  **P1.1.10 recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits** | This covers two lessons:  **Engage:** Show pictures of warning signs from types of radiation. Get learner feedback as to what the dangers may be, eliciting prior knowledge and understanding.  **Explore:** Research task where pupils are put into groups each group asked to produce a brochure / leaflet / poster / PowerPoint about the hazards and uses of a type of radiation from the EM spectrum. Make sure all areas of the spectrum are covered within the class. Some useful websites may be:  <http://www.nhs.uk/conditions/Radiation/Pages/Introduction.aspx>  <http://www.health.harvard.edu/newsletter_article/Radiation-in-medicine-a-double-edged-sword>  **Explain:** Groups now have to teach the rest of the class about their area of the EM spectrum  **Extend:** [Foundation depth in physics](http://www.ocr.org.uk/Images/234633-unit-j259-02-depth-in-physics-foundation-tier-sample-assessment-material.pdf), 259/02, sample assessment Question 2  **Evaluate:**  RAG chapter P1.1 to assess pupils understanding | Link to Topic exploration pack [EM waves](http://www.ocr.org.uk/Images/222387-em-waves-teacher-pack-topic-exploration-pack.pdf)  Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](http://www.ocr.org.uk/Images/234633-unit-j259-02-depth-in-physics-foundation-tier-sample-assessment-material.pdf) |

# Outline Scheme of Work: P1 – Radiation and Waves

## Total suggested teaching time – 22 hours

### P1.2 What is climate change and what is the evidence for it? (3 hours)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * the composition of the atmosphere * the production of carbon dioxide by human activity and the impact on climate | |
| Links to Mathematical Skills  * NA | Links to Mathematical Skills  * NA |

# Overview of P1.2 What is climate change and what is the evidence for it?

| Lesson | Statements | Teaching activities | Notes |
| --- | --- | --- | --- |
| 1 (1hr for separate and combined) | P1.2.1 explain that all bodies emit radiation, and that the intensity and wavelength distribution of any emission depends on their temperatures | **Engage**: Display a picture of the sun and the earth and get pupils to give ideas of how the heat radiation gets from the sun to the earth.  You may need to give information about space and the lack of particles. Pupils may link to conduction or convection and will need some guidance.  **Explore:** explore heat radiation with a beakers of water placed at different distances from a heat lamp. How does the distance affect the heating effect on the water? (Putting foil behind the beaker and “tunnelling” the heat from the lamp will increase the heating effect).  **Explain:** Discuss experiment results. What would happen is the intensity of the heat source increased? Link temperature to wavelength.  **Extend:** History of atmospheric CO2 levels.  A [video](https://www.youtube.com/watch?v=t0dXjmoA0dw) showing atmospheric CO2 levels over time with information about data sources. More ways to scare learners with the incredibly short timescale over which recent climatic changes have occurred when compared with historical data.  **Evaluate:** Link to astronomy by showing pictures of stars, students should be able to point out hotter and cooler stars from their colour (but should recognise that the brightness will vary according to distance as well as temperature). | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf) |
| 2 and 3 (2hr for separate and combined) | **P1.2.2 explain how the temperature of a body is related to the balance between incoming radiation, absorbed radiation and radiation emitted; illustrate this balance, using everyday examples including examples of factors which determine the temperature of the Earth** | **Engage:** [Video](https://www.youtube.com/watch?v=sTvqIijqvTg) – how do greenhouse gases actually work?  **Explore:** An [experimental model](http://www.carboeurope.org/education/CS_Materials/AnExperimental%20Model.pdf) to understand temperature regulation.  An open-ended experimental framework to enable learners to visualise what happens when different layers of reflection and absorption intermediate between a surface and a radiation source. Since the long version of this experiment can take a long time, it is perhaps advisable to set up several versions of the experiment instead of varying conditions in just the one experimental setup. It should be stressed that this is merely a model, and not in itself evidence of anthropogenic climate change.  **Explain:** Pupils can research the reasons for climate change and feedback findings to class. The following websites can be used to find information:  <https://www.epa.gov/environmental-topics>  <http://www.bloomberg.com/graphics/2015-whats-warming-the-world/>  **Extend:** An [interactive resource](http://scied.ucar.edu/simple-climate-model) which projects temperature change over time based on CO2 emissions. Have fun scaring learners by showing them that even keeping CO2 emissions at current levels will continue to increase atmospheric temperature at an alarming rate.  Or  A web based [flash game](http://www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/) in which you play the President of Europe and have to make various political and economic decisions affecting CO2 emissions.  **Evaluate**: RAG chapter P1.2 to assess pupils understanding | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf) |

# Outline Scheme of Work: P1 – Radiation and Waves

## Total suggested teaching time – 22 hours

### P1.3 How do waves behave? (7 hours)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * know the meaning of the terms longitudinal, transverse, superposition and frequency * know that sound waves are longitudinal and need a medium to travel through and that sound travels at different speeds in solids, in water and in air * know that sound is produced when objects vibrate and that sound waves are detected by the vibrations they cause | |
| Links to Mathematical Skills  * M1a * M1c * M3c * M3d | Links to Practical Activity Groups (PAGs)  * PAG 4 – describe how to use a ripple tank to measure the speed/frequency and wavelength of a wave * PAG 8 – describe how to investigate the reflection of light off a plane mirror and the refraction of light through a rectangular prism |

# Overview of 1.3 How do waves behave?

| Lesson | Statements | Teaching activities | Notes |
| --- | --- | --- | --- |
| 1 (1hr for separate and combined) | P1.3.1 describe wave motion in terms of amplitude, wavelength, frequency and period  P1.3.2 describe evidence that for both ripples on water surfaces and sound waves it is the wave and not the water or air itself that travels | Engage: Keyboard activity:Use a keyboard to illicit pupils’ prior knowledge. Give pupils cards that say high frequency, low frequency, high amplitude, low amplitude. Play at high and low frequencies and amplitudes and get pupils to hold up the card that best describes the sound.Explore: What is a wave? A web page containing interactive demonstrations of wave behaviour.  [View full activity in P1.3 How do waves behave? – Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg003-p13-how-do-waves-behave?activity=288492#288492) Explain: Wave machine demonstration A wave machine made from wooden skewers, duct tape and jelly babies. Simple enough to build in the classroom, this also involves sweets, although non-edibles can be substituted if necessary.  [View full activity in P1.3 How do waves behave? – Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg003-p13-how-do-waves-behave?activity=288506#288506)  **Extend:** Mexican wave:  Get the pupils to do a Mexican wave. Tell them to change the wave with increasing/decreasing amplitude/frequency.  **Evaluate:** [SAM](https://www.ocr.org.uk/Images/234633-unit-j259-02-depth-in-physics-foundation-tier-sample-assessment-material.pdf) question: Depth in Physics Foundation J259-02Question 1 | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](https://www.ocr.org.uk/Images/234633-unit-j259-02-depth-in-physics-foundation-tier-sample-assessment-material.pdf) |
| 2 (1hr for separate and combined) | P1.3.3 describe the difference between transverse and longitudinal waves  P1.3.4 describe how waves on a rope are an example of transverse waves whilst sound waves in air are longitudinal waves | **Engage:** Rope and Slinky: Get pupils to make different types of waves using ropes and Slinky’s. Get pupils to model waves of different amplitudes and frequencies. Pupils should know the difference between longitudinal and transverse waves from KS3, this is a good opportunity to test this knowledge.  **Explore:** The [Mantis Shrimp](https://www.youtube.com/watch?v=glOsvm9t7ec) **–** most complex eyes in the animal kingdom  A short video about an animal that can see infrared, ultraviolet and two types of polarised light.  **Explain:** Waves using trolleys  <https://spark.iop.org/waves-trolleys#gref>  A demonstration of transverse and longitudinal waves using trolleys. Another simple classroom experiment, this also has the advantage of demonstrating both longitudinal and transverse waves.  **Extend:** Polarising filters **–** Why do these work only on transverse waves?  **Evaluate:** [SAM](http://www.ocr.org.uk/Images/234626-unit-j249-02-physics-foundation-tier-paper-2-sample-assessment-material.pdf) question:J249-02 Question 22 | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](http://www.ocr.org.uk/Images/234626-unit-j249-02-physics-foundation-tier-paper-2-sample-assessment-material.pdf) |
| 3 (1hr for separate and combined) | P1.3.5 define wavelength and frequency  P1.3.6 recall and apply the relationship between speed, frequency and wavelength to waves, including waves on water, sound waves and across the electromagnetic spectrum:  wave speed (m/s) = frequency (Hz) x wavelength (m)  M1a, M1c, M3c, M3d | Engage: Virtual keyboard with frequency display and oscilloscope PCCL <http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/oscilloscope_description_tutorial_sounds_frequency.htm>Explore: Measure the speed of sound A simple activity in which learners measure the speed of sound using an echo. Variations on this experiment include measuring the speed of sound under different conditions (temperature, humidity, etc.).  [View full activity in P1.3 How do waves behave? – Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg003-p13-how-do-waves-behave?activity=288496#288496)  **Explain:** Measure the speed of light with chocolate  A simple activity in which learners measure the speed of sound using an echo. Variations on this experiment include measuring the speed of sound under different conditions (temperature, humidity, etc.).  [View full activity in P1.3 How do waves behave? – Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg003-p13-how-do-waves-behave?activity=288512#288512)  **Extend:** Calculation practice**:** Give pupils plenty of practice in calculations, rearranging of equation, and converting between Hz and kHz, m and cm.  **Evaluate:** SAMs question**:** Breadth in Physics HT, J259/03, Question 5. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](http://www.ocr.org.uk/Images/234635-unit-j259-03-breadth-in-physics-higher-tier-sample-assessment-material.pdf) |
| 4 (1hr for separate and combined) | P1.3.7 a) describe how the speed of ripples on water surfaces and the speed of sound waves may be measured  b) describe how to use a ripple tank to measure the speed/frequency and wavelength of a wave  *PAG4* | **Engage:** Demo ripple tank  **Explore:** Estimating wavelength, frequency and velocity of ripples - Nuffield Foundation  <https://spark.iop.org/estimating-wavelength-frequency-and-velocity-ripples>  **Explain**: [**PAG4**](https://www.ocr.org.uk/Images/311749-pag-activity-physics-measuring-waves-suggestion-1.docx)  **Extend:** Use blocks to create smaller openings so pupils can investigate interference patterns  **Evaluate**: Give pupils the [Learner record sheet](https://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc). Pupils to tick of skills covered. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [learner record sheet](https://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) |
| 5 (1hr for separate and combined) | P1.3.8 a) describe the effects of reflection and refraction of waves at material interfaces  b) describe how to measure the refraction of light through a prism  *PAG8*  c) describe how to investigate the reflection of light off a plane mirror  *PAG8* | **Engage: Images of refracted light showing optical illusions.** e.g. pencil in a beaker, fish in water. Ask pupils what is happening here.  **Explore:** demo experiments  **Explain:** PAG 8: reflection of light of a plane mirror.  **Extend:** PAG 8: refraction of light through a rectangular prism.  **Evaluate:** Give pupils the Learner record sheet. Pupils to tick of skills covered. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [learner record sheet](https://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc)  Link to [PAG 8](https://www.ocr.org.uk/Images/317638-pag-activity-physics-interaction-of-waves-suggestion-1.docx) |
| 6 (1hr for separate and combined) | **P1.3.9 recall that waves travel in different substances at different speeds and that these speeds may vary with wavelength**  **P1.3.10 explain how refraction is related to differences in the speed of the waves in different substances** | **Engage:** Dispersion of light through a prism  **Explore:**[Experiments](https://www.youtube.com/watch?v=gDA_nDXM-ck) in refraction, reflection and total internal reflection.  **Explain:** Pupils investigate refraction through different mediums.  **Extend:** Refraction interactive at Physics classroom <http://www.physicsclassroom.com/Physics-Interactives/Refraction-and-Lenses/Refraction/Refraction-Interactive>  **Evaluate:** [Sample assessment question](http://www.ocr.org.uk/Images/234636-unit-j259-04-depth-in-physics-higher-tier-sample-assessment-material.pdf)**.** Higher depth in physics, J259/04, Q5a and b | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to [SAM](http://www.ocr.org.uk/Images/234636-unit-j259-04-depth-in-physics-higher-tier-sample-assessment-material.pdf) |
| 7 (1hr for separate and combined) | P1.3.11 recall that light is an electromagnetic wave  P1.3.12 recall that electromagnetic waves are transverse | **Engage:** [Electromagnetic spectrum song](https://www.youtube.com/watch?v=bjOGNVH3D4Y)  **Explore:** Newton’s prism experiments from Creative Science Centre <http://www.creative-science.org.uk/prism.html>  A version of Newton’s experiments with prisms that demonstrate with refraction the hypothesis that white light contains a mixture of different colours. Perhaps useful to relate to Herschel’s infrared experiment and others mentioned in 1.1.  **Explain**: Pupils use prisms to split white light into the spectrum of colours  **Extend:** Transverse vs longitudinal**:**  Pupils to write down the differences between these two types of waves. Teacher then gives them examples of waves and pupils are to say whether they are transverse or longitudinal.  **Evaluate:** RAG for P1.3 to assess pupils understanding of the chapter. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf) |

# Outline Scheme of Work: P1 – Radiation and Waves

## Total suggested teaching time – 22 hours

### P1.4 What happens when light and sound meet different materials? (separate science only) (7 hours)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * be able to use a ray model of light to describe and explain reflection in mirrors, refraction and dispersion by glass and the action of convex lenses * know that light incident on a surface may be absorbed, scattered, or reflected, and that light transfers energy from a source to an absorber, where it may cause a chemical or electrical effect | |
| Links to Mathematical Skills  * M1c * M3c * M5a * M5b | Links to Practical Activity Groups (PAGs)  * NA |

# Overview of P1.4 What happens when light and sound meet different materials?

| Lesson | Statements | Teaching activities | Notes |
| --- | --- | --- | --- |
| 1 (separate science only) | P1.4.1 construct and interpret two-dimensional ray diagrams to illustrate specular reflection by mirrors  *qualitative only*  M5a, M5b | Engage: Reflection images: mirrors in water. Show a variety of reflected images.Explore: [Science Primer](http://scienceprimer.com/specular-diffuse-reflection)A web page containing an interactive graphic to help visualise the difference between specular and diffuse reflection.Explain: Ray diagramsWork through with pupils how to draw ray diagrams of reflection. After going through a couple of examples, pupils should be given the opportunity to practice drawing these.Extend: Refraction interactive An interactive tool simulating refraction and reflection of light in different media.  [View full activity in P1.4 What happens when light and sound meet different materials? - Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg004-p14-what-happens-when-light-and-sound-meet-different-materials?activity=288622#288622)  **Evaluate:** Pupils to write down the key things to remember when drawing ray diagram. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: What happens when light and sound meet different materials?  <https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc> |
| 2 (separate science only) | P1.4.2 construct and interpret two-dimensional ray diagrams to illustrate refraction at a plane surface and dispersion by a prism  *qualitative only*  M5a, M5b | Engage: [Experiments](https://www.youtube.com/watch?v=gDA_nDXM-ck) in refraction, reflection and total internal reflectionExplore: Direction of bending at The Physics Classroom: <http://www.physicsclassroom.com/class/refrn/Lesson-1/The-Direction-of-Bending>A page of explanations and analogies designed to help remind learners how waves will refract in different media. A fairly comprehensive catalogue of analogies, which includes links to interactive resources near the bottom of the page.Explain: Work through with pupils how to draw ray diagrams of refraction and dispersion. After going through a couple of examples, pupils should be given the opportunity to practice drawing these.Extend: Refraction of sound A short video about refraction of sound in warm and cold air.  [View full activity in P1.4 What happens when light and sound meet different materials? - Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg004-p14-what-happens-when-light-and-sound-meet-different-materials?activity=288716#288716) Evaluate: Pupils to write their own definitions of reflection, refraction and dispersion and to give an example of each. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: [What happens when light and sound meet different materials?](https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc) |
| 3 (separate science only) | P1.4.3 use ray diagrams to illustrate the similarities and differences between convex and concave lenses  *qualitative only* | Engage: Images of telescopes, cameras, microscopes, glasses. What do these have in common?Explore: Pupils to investigate with convex and concave lenses. Let pupils explore these and feedback what the different type of lenses do to the light. Pupils should be encouraged to draw what they think the ray diagrams for these would look like.Explain: Work through with pupils how to draw ray diagrams for convex and concave lenses. After going through a couple of examples, pupils should be given the opportunity to practice drawing these.Extend: Pupils to produce their own revision booklet showing all the lens diagrams covered so far.Evaluate: Show lens diagrams and pupils to say what the diagram is showing; reflection, refraction, dispersion, convex or concave lens. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: [What happens when light and sound meet different materials?](https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc) |
| 4 (separate science only) | P1.4.4 describe the effects of transmission, and absorption of waves at material interfaces  P1.4.5 explain how colour is related to differential absorption, transmission, and scattering | Engage: Light absorption, reflection and transmission A video illustrating how colour relates to transmission, reflection and absorption of light, using gummy bears.  [View full activity in P1.4 What happens when light and sound meet different materials? - Online delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-physics-b-j259-from-2016/delivery-guide/topic-gpbt01-p1-radiation-and-waves/delivery-guide-gpbdg004-p14-what-happens-when-light-and-sound-meet-different-materials?activity=288690#288690)  **Explore:** Activity A1: basic experiments with colour**.**  SeeTopic exploration pack: What happens when light and sound meet different materials?  **Explain:** Activity A2: spectroscopy for beginners**.**  SeeTopic exploration pack: What happens when light and sound meet different materials?  **Extend:** Activity A3: Why is the sky blue?  SeeTopic exploration pack: What happens when light and sound meet different materials?  **Evaluate:** Pupils to write definitions of the key words: transmission, absorption and scattering and then write in their own words how they relate to colour. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: [What happens when light and sound meet different materials?](https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc) |
| 5 (separate science only) | **P1.4.6 describe, with examples, processes in which sound waves are transmitted though solids**  **P1.4.7 explain that transmission of sound through the bones in the ear works over a limited frequency range, and the relevance of this to human hearing**  P1.4.9 show how changes, in speed, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related  M1c, M3c | Engage: This [video](https://www.youtube.com/watch?v=mY-f68J5PPo) could be used to show how a drum sound depends on where the drum is played.Explore: Speed of sound in different media can be explored by showing this [video](https://www.youtube.com/watch?v=-ANOqBvPI90).Explain: Use ear model to explain how we hear sounds. Compare hearing ranges of different animals. Using a signal generator you can also slowly increase the frequency of the sound and get pupils to sit down when they can no longer hear the sound. The teacher will normally sit before the pupils and this shows how the top end of frequency we can hear decreases with age.Extend: Activity B2: Harmonics from Topic exploration pack: What happens when light and sound meet different materials?Evaluate: Pupils to write the journey of a sound from when it is made to when it is heard in the ear. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: [What happens when light and sound meet different materials?](https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc) |
| 6 (separate science only) | **P1.4.8 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:**  **a) in our bodies (ultrasound imaging)**  **b) in the Earth (earthquake waves)**  **c) in deep water (SONAR).** | Engage: Show images of ultrasound, earthquakes and sonar. Ask what these have in common?Explore: Split class into small groups. Groups to choose to research one of the uses of these waves for either:  * Ultrasound * Earthquake detection * SONAR  Explain: Pupils work in groups to research their chosen topic; they must create a presentation and fact sheet for the rest of the class.Extend: Pupils present, class take notesEvaluate: Pupils create a table giving the key information on each of the uses researched by the class. | Link to Delivery guide [Radiation and Waves](https://www.ocr.org.uk/Images/271964-radiation-and-waves-delivery-guide.pdf)  Link to topic exploration pack: [What happens when light and sound meet different materials?](https://www.ocr.org.uk/Images/298838-what-happens-when-light-and-sound-meet-different-materials-topic-exploration-pack.doc) |
| 7 | Chapter P1 End of topic quiz | Pupils to complete the end of [chapter quiz P1](https://interchange.ocr.org.uk/Downloads/Twenty-First-Century-Physics-Quizzes.zip). After completion pupils to swap and mark quizzes.Pupils use their quizzes to create a revision list from Chapter 1 | You will need an OCR Interchange login to access this quiz. |

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