# Scheme of work

## Physics – Waves

This resource provides guidance for teaching the Waves topic from our new GCSE Physics (8463). It has been updated from the draft version to reflect the changes made in the accredited specification. There are many changes throughout the document, particularly to the learning outcomes and the opportunities to develop skills columns.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 4.6.1 Waves in air, fluids and solids

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.1.1 | Features of transverse and longitudinal waves. | Waves may be either transverse or longitudinal.  In a transverse wave the oscillations are perpendicular to the direction of energy transfer. The ripples on a water surface are an example of a transverse wave.  In a longitudinal wave the oscillations are parallel to the direction of energy transfer. Longitudinal waves show areas of compression and rarefaction. Sound waves travelling through air are longitudinal.  Describe evidence that for both ripples on a water surface and sound waves in air, it is the wave and not the water or air that travels. | 1 | Draw diagrams to show the features of transverse and longitudinal waves.  Give examples of both transverse and longitudinal waves.  Describe the propagation of both transverse and longitudinal waves.  Explain the changes in air pressure caused by longitudinal waves in regions of compression and rarefaction. | What do waves look like?  Do all waves have the same properties?  Demonstrate how waves travel using a slinky spring.  Investigate waves in a ripple tank. What can you change to increase the frequency of the wave? If a ripple tank isn’t available, show the following two clips from [Open University](https://www.youtube.com/watch?v=y53z2zVipAs).  Activities listed on Institute of Physics website [Episode 309](http://tap.iop.org/vibration/progressive/309/page_46635.html) | [BBC Bitesize: General properties of waves](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/waves/generalwavesrev2.shtml)  [Cyber Physics: Waves](http://www.cyberphysics.co.uk/topics/waves/gcsewaves.html)  GCSE Boardworks – Waves section  Mini White Boards (MWB) Q&A session based around activities listed on Boardworks and/or teacher’s own questions.  [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 4.6.1.2 | Properties of waves.  Equation linking the wave speed, frequency and wavelength should be known. | Waves are described by their amplitude, wavelength, frequency and period.  The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.  The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.  The frequency of a wave is the number of waves passing a point each second.  period, *T*, in seconds, s frequency, *f*, in hertz, Hz  The period of a wave is how long it takes for one wave to pass a point.  The wave speed is the speed at which the energy is transferred (or the wave moves) through the medium.  All waves obey the wave equation:    wave speed, *v*, in metres per second, m/s  frequency, *f*, in hertz, Hz  wavelength, *λ*, in metres, m  Describe methods to measure the speed of sound waves in air, and the speed of ripples on a water surface.  Show that when sound waves travel from one medium to another the changes in velocity, frequency and wavelength are inter-related. (physics only). | 2 | Define:   * wavelength * amplitude * frequency * peak * trough * period.   Calculate the wavelength of a wave from a labelled diagram of a wave.  Calculate the frequency of a wave given the number of waves (possibly from interpreting a diagram) and the time.  Calculate the speed of a wave. Rearrange the equation to find any unknown given the other two values. | What do waves do?  What effect does increasing the amplitude/ frequency of a sound wave have?  Demonstrate the above using a loudspeaker and signal generator connected to an oscilloscope. Vary the frequency and then the amplitude on the signal generator – what is observed?  Demonstrate that changing the frequency of a transverse wave on a length of rope changes the wavelength.  Pupils could investigate how to accurately measure the period of a wave, ie time a fixed number, say 10 and then divide the time by this number.  What is the speed of sound?  What factors change the speed of sound?  Research the speed of sound and the factors that affect it.  Can we measure the speed of sound in school?  Required practical:    Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements. (8.2.8)  Find the speed of sound by measuring the time taken for an echo to get back to you after clapping your hands or banging two large lumps of wood together, near a wall. The distance to the wall will need to be measured (and doubled to find the distance the sound wave travels).  Find the speed of ripples on a water surface using a ripple tank. | [Revision summary: waves](http://www.s-cool.co.uk/gcse/physics/properties-of-waves/remember-it/s-cool-revision-summary)  [Anatomy of a wave](http://www.physicsclassroom.com/class/waves/Lesson-2/The-Anatomy-of-a-Wave)  [Cyber Physics: Waves](http://www.cyberphysics.co.uk/topics/waves/gcsewaves.html)  [The frequency and period of a wave](http://www.physicsclassroom.com/class/waves/Lesson-2/Frequency-and-Period-of-a-Wave)  GCSE Boardworks – Waves section  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.1.3 | Reflection of waves. (physics only) | Waves can be reflected at the boundary between two different materials.  Waves can be absorbed or transmitted at the boundary between two different materials. | 1 | Construct labelled ray diagrams to illustrate the reflection of a wave at a surface.  State the law of reflection.  Describe and explain the effect of a wave moving from one medium into another.  Explain why reflection of sound at a smooth bare surface leads to echoes.  Explain why at night refraction of sound leads to sounds being heard from further afield than during daytime. | Critically analyse models of light that explain refraction, eg a car travelling into a puddle of water.  Required practical: (physics only)    Investigate the reflection of light by different types of surface and the refraction of light by different substances. (8.2.9)  Investigate the law of reflection using a plane mirror and ray box. Pupils measure the angles of incidence and reflection.  Demonstrate/investigate refraction of light using a straw in a glass of water, or use of a ray box and rectangular prisms. Pupils measure angles of incidence and refraction. | Reflection of waves:  [BBC Bitesize: General properties of waves](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/waves/generalwavesrev6.shtml)  [Cyber Physics: Reflection](http://www.cyberphysics.co.uk/topics/light/reflection.htm)  MWB Q&A based on teacher’s questions  [Cyber Physics: Refraction](http://www.cyberphysics.co.uk/topics/light/refraction.htm)  MWB Q&A based on teacher’s questions |
| 4.6.1.4 | How we hear sound. HT only (physics only) | Sound waves can travel through solids causing vibrations in the solid. Within the ear, sound waves cause the ear drum and other parts to vibrate which causes the sensation of sound. The conversion of sound waves to vibrations of solids works over a limited frequency range. This restricts the limits of human hearing. | 1 | State the range of human hearing.  Explain why sound waves travel faster in solids than they do in liquids and gases.  Interpret data on the speed of sound to draw conclusions about the type of material that the wave is travelling through.  Describe how sound waves travel from a source to the ear and the effect that this has inside the ear.  Describe sound waves in terms of pitch and frequency.  Describe and explain why ear defenders are a required piece of safety equipment when using pneumatic drills. | Can you hear explosions in space?  What does a sound wave look like?  How does the hearing range of a person change over their life-time?  Can conduct a hearing test with pupils having a signal generator connected to a loud speaker.  Demonstrate an alarm clock in a bell jar connected to a vacuum pump. Ask students what is scientifically wrong about this clip of [Star Wars](https://www.youtube.com/watch?v=qniy8aDSFLA&feature=related)  Research the speed of sound in air, water and steel. Use the speeds to explain why you can hear talking in water but cannot understand it.  Plan an investigation to find the best type of ear plug for a given situation (working with heavy machinery, sitting on a motorcycle, etc). | [How do we hear?](http://www.dangerousdecibels.org/virtualexhibit/2howdowehear.html)  [BBC Bitesize: Human hearing and the speed of sound](http://www.bbc.co.uk/education/guides/zwjsgk7/revision/2)  [How the ear works](https://www.youtube.com/watch?v=EEvwwGui2Ac) |
| 4.6.1.5 | Uses of waves in imaging, sonar and developing theories on the structure of the Earth. HT only (physics only) | Different types of wave can be used for the detection and exploration of structures/ objects that cannot be seen directly by the eye.   * Ultrasound waves have a frequency higher than the upper limit of hearing for humans. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector can be used to determine how far away such a boundary is. This allows ultrasound waves to be used for both medical and industrial imaging. * Seismic waves are produced by earthquakes. P-waves are longitudinal, seismic waves. P-waves travel at different speeds through solids and liquids. S-waves are transverse, seismic waves. S-waves cannot travel through a liquid. P-waves and S-waves provide evidence for the structure and size of the earth’s core.   Echo sounding, using high frequency sound waves is used to detect objects in deep water and measure water depth. | 2 | Give similarities and differences between sound waves and ultrasound waves.  State uses of ultrasound waves.  Describe and explain how ultrasound waves are used to build up a picture of the inside of a human body.  Give advantages and disadvantages of using ultrasound waves for diagnosis.  Perform calculations on ultrasound scans using the equation:  distance = speed x time  State that P-waves and S-waves are types of seismic wave.  Describe the properties of P-waves and S-waves.  Describe and explain how P-waves and S-waves travel through the Earth’s interior, and how this allows us to build up a picture of the Earth’s interior.  Explain how earthquakes are detected and the scale that they are measured on.  Describe and explain how echo sounding is used in a given situation, eg, to find the depth of the ocean or to find fish when sea fishing. | Is an ultrasound baby scan dangerous?  How does an ultrasound wave differ from a sound wave?  How is an image of a foetus built up in an ultrasound scan?  Research how ultrasound imaging works.  Find out how ultrasound is used in both diagnosis and treatment of hospital patients.  Which type of seismic wave travels the fastest?  Why do tsunamis happen?  How can you make building earthquake proof?  How can you detect seismic waves?  How do seismic waves allow us to build up a picture of the Earth’s interior?  Build a simple seismometer and test by jumping up and down.  Design an earthquake proof building.  Research the Richter scale used to measure the strength of earthquakes. If the earthquakes goes from 2 to 6 how much more energy is released?  Use echo sounding to determine either the speed of sound or distance to an object. | Ultrasound scans:  [BBC Bitesize: Ultrasound](http://www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/radiation/ultrasoundrev2.shtml)  [Cyber Physics: Ultrasound](http://www.cyberphysics.co.uk/topics/waves/ultrasound.htm)  [YouTube clip on how ultrasound builds up a picture of a foetus](https://www.youtube.com/watch?v=GvbXHoiQHbI)  Seismic waves:  [BBC Bitesize: P and S waves](http://www.bbc.co.uk/schools/gcsebitesize/science/21c/earth_universe/seismic_wavesrev1.shtml)  [Seismic Waves](http://www.cyberphysics.co.uk/topics/earth/geophysics/SeismicWaves.htm)  [P waves](http://www.cyberphysics.co.uk/topics/earth/geophysics/SeismicWavesP.html)  [S waves](http://www.cyberphysics.co.uk/topics/earth/geophysics/SeismicWavesS.html)  [How a blind boy uses echolocation](https://www.youtube.com/watch?v=r9mvRRwu5Gw) |

### 4.6.2 Electromagnetic waves

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop scientific communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.2.1 | The electromagnetic spectrum | Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.  Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.  The waves that form the electromagnetic spectrum are grouped in terms of their wavelength and their frequency. Going from long to short wavelength (or from low to high frequency) the groups are: - radio, microwave, infra-red, visible light (red to violet), ultra-violet, X-rays and gamma-rays.  Our eyes detect visible light and so only detect a limited range of electromagnetic waves. | 1 | Describe the properties common to all electromagnetic waves.  State that electromagnetic waves transfer energy from one place to an absorber of that energy.  Name the seven types of electromagnetic wave, in the correct order from longest to shortest wavelength.  State the range of wavelengths is approximately 10-15m – 104m  State that the only part of the electromagnetic spectrum that our eyes can detect is visible light. | How do the electromagnetic waves differ from each other?  How is the speed of light measured?  Pupils can try and come up with a mnemonic to remember the order of the visible light spectrum.  Research how the speed of light was found.  Research the parts of the electromagnetic spectrum seen by animals, eg cats, bees, snakes. | [Waves in the spectrum](http://www.s-cool.co.uk/gcse/physics/uses-of-waves/revise-it/electromagnetic-spectrum)  [The electromagnetic spectrum: the family of light](http://www.cyberphysics.co.uk/topics/light/emspect.htm)  [BBC Bitesize: Using the spectrum](http://www.bbc.co.uk/bitesize/standard/physics/health_physics/using_the_spectrum/revision/1/)  GCSE Boardworks – Electromagnetic Waves section  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.2.2 | Properties of electromagnetic waves. | Construct ray diagrams to illustrate the refraction of a wave.  Different wavelengths of electromagnetic waves are reflected, refracted, absorbed or transmitted differently by different substances and types of surface. HT only.  Some effects, for example refraction, are due to the difference in velocity of the waves in different substances.  Refraction does not happen when a wave enters a medium at 90o to the surface. HT only.  Use wave front diagrams to explain refraction in terms of the change of speed that happens when a wave travels from one medium to a different medium. HT only | 1.5 | Construct ray diagrams to illustrate the refraction of a wave at the boundary between two different media. | Why can I get TV signal at home but not a mobile phone signal?  Demonstration of the properties of microwaves using a microwave transmitter and a detector connected to a millimetre.  If you didn’t complete the refraction experiments detailed in section ‘Reflection of waves’ then complete them here.  If you have a ripple tank you can demonstrate refraction as waves go into different depths of water, or use this video on [Ripple tank reflection](https://www.youtube.com/watch?v=R5EdLv3NS7Y)  Required practical :  Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface. (8.2.10)  Investigate how the type of surface affects the amount of infrared radiation absorbed by a surface.  Investigate how the colour of a surface affects how quickly an object will cool by the emission of infrared radiation. Use a Leslie cube or a ‘home-made’ version. | [BBC Bitesize: Refraction and diffraction](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/waves/generalwavesrev5.shtml)  [Reflection, refraction and diffraction](http://www.physicsclassroom.com/class/waves/Lesson-3/Reflection,-Refraction,-and-Diffraction)  GCSE Boardworks – Electromagnetic Waves section  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.2.3 | Radio waves and electrical circuits.  How electromagnetic waves are generated.  The effects of gamma rays, X-rays and ultraviolet waves on the body. | Changes in atoms and the nuclei of atoms can result in electromagnetic waves being generated or absorbed over a wide frequency range. Gamma rays originate from changes in the nucleus of an atom.  Radio waves can be produced by oscillations in electrical circuits. HT only.  When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can also produce oscillations in an electrical circuit. HT only.  Ultra-violet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose. Radiation dose (in Sieverts) is a measure of the damage caused by the radiation in the body.  Ultra-violet waves can cause skin to age prematurely and increase the risk of skin cancer. X-rays and gamma rays are ionising radiation that can cause mutation of genes and cancer. | 2 | Describe how electromagnetic waves are generated.  Describe how radio waves can be produced in electrical circuits and also the effect that radio waves may have on electrical circuits.  Explain why atoms only absorb certain frequencies of electromagnetic radiation  Describe gamma radiation as being a type of electromagnetic radiation emitted from the nucleus of an unstable atom.  Describe and explain the effects that gamma, X-rays and ultraviolet radiation have on the body.  Explain how the radiation dose that nuclear industry workers are exposed to is measured.  Explain how a radiation badge detects radiation.  Draw conclusions from given data about the risks and consequences of exposure to radiation. Students will not need to recall the unit of radiation dose.  Describe how ultraviolet radiation from the sun can affect the body and in particular the skin. | How do radios work?  Make a simple transistor radio.  Research the first radio communication sent across the Atlantic.  How do you make an electromagnetic wave?  Is radiation harmful?  Does sunbathing cause cancer?  Are sunbeds safer than sunbathing?  How I can I reduce the risk of skin cancer?  Do people working in a nuclear power station have a greater risk of cancer?  Research the radiation dose level people in various professions are exposed to eg nuclear industry, pilot, science teacher.  Plan an investigation to find out which sun screen is the most effective - probes are available for data loggers to measure the intensity of ultraviolet light.  Research into how exposure to gamma rays, X-rays and ultraviolet light can cause cell mutations. | [Cyber Physics: Radio and TV waves](http://www.cyberphysics.co.uk/topics/waves/radiowaves/radio.htm)  GCSE Boardworks – Radiowaves and Microwaves section  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions.  [Cyber Physics: The electromagnetic spectrum – the family of light](http://www.cyberphysics.co.uk/topics/light/emspect.htm)  GCSE Boardworks – Ionizing Radiation section  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions.  [Dangers of ionising radiation](http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/energy/safehandlingradmatrev1.shtml)  [Cyber Physics: The electromagnetic spectrum – the family of light](http://www.cyberphysics.co.uk/topics/light/emspect.htm)  [Harmful effects of ultraviolet radiation](http://enhs.umn.edu/current/5103/uv/harmful.html) |
| 4.6.2.4 | Uses of electromagnetic waves. | Electromagnetic waves have many practical applications. For example:   * radio waves – television and radio * microwaves – satellite communications, cooking food * infrared – electrical heaters, cooking food, infra-red cameras * visible light – fibre optic communications * ultraviolet – energy efficient lamps, sun tanning * X-rays – medical imaging and treatments.   Explain why each type of electromagnetic wave is suitable for the practical application. HT only. | 0.5 | Give the order of the electromagnetic spectrum.  Describe uses of each wave in the electromagnetic spectrum.  Explain the suitability of each wave for its practical application. (HT only)  Suggest reasons why an electromagnetic wave may not be suitable for a given application. (HT only)  Produce a leaflet to show the uses and dangers of electromagnetic radiation.  Explain the precautions taken in a hospital when carrying out an X-ray. Precautions should include steps taken to reduce the risks for the patient and the radiographer. | Where are electromagnetic waves used?  Why are some types of electromagnetic waves used when they are dangerous?  Research the various uses of electromagnetic waves and how they are suitable for that application. (HT only)  Research the use of laser light in barcodes and in reading CDs.  Demonstrate an optical fibre showing total internal reflection.  Demonstrate a use of UV by shining a UV light onto a bank note, through tonic water or writing a message using a security marker and then holding a UV light over the message. | [BBC Bitesize: The electromagnetic spectrum](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/waves/soundandlightrev2.shtml)  [Cyber Physics: The electromagnetic spectrum](http://www.cyberphysics.co.uk/topics/light/emspect.htm)  GCSE Boardworks – various sections  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.2.5 | Concave and convex lenses. (physics only) | A lens forms an image by refracting light. In a convex lens, parallel rays of light are brought to a focus at the principal focus. The distance from the lens to the principal focus is called the focal length. Ray diagrams are used to show the formation of images by convex and concave lenses.  The image produced by a convex lens can be either real or virtual. The image produced by a concave lens is always virtual.  The magnification produced by a lens can be calculated using the equation:  Magnification is a ratio and so has no units.  Image height and object height should both be measured in either mm or cm. | 1 | Construct ray diagrams to show how light travels through concave and convex lenses.  Describe the key features of a ray diagram where light passes through a lens. Students should be able to identify the:   * Principal axis * Principal focus * Focal length.   Explain the difference between real and virtual images.  State situations where real images and virtual images are produced.  Construct ray diagrams for a camera, a projector and a magnifying glass using a convex lens.  Calculate the magnification of a lens using the magnification equation.  Use the correct terminology when describing the image produced by a lens, eg real, magnified and inverted for a projector. | Investigate convex lenses. Using a single convex lens show how a camera can produce an image onto a photographic film. Show how when the object being looked at is further way than the focal length then the image is inverted.  Research the use of lenses to correct short-sightedness and long-sightedness.  Investigate the magnification of a magnifying glass and a microscope. | [Convex and concave lenses](http://www.bbc.co.uk/bitesize/standard/physics/health_physics/light_and_sound/revision/2/)  Ray diagrams with lenses:  [BBC Bitesize: Investigating lenses](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/space_for_reflection/optics/revision/2/)  [Cyber Physics: Lenses](http://www.cyberphysics.co.uk/topics/light/lenses.htm)  MWB Q&A based on ray diagrams and descriptions of them. |
| 4.6.2.6 | How we see the colour of an object. (physics only) | Each colour within the visible light spectrum has its own narrow band of wavelength and frequency. The colour of an object is related to the reflection, absorption and transmission of different wavelengths of light by the object.  Reflection from a smooth surface in a single direction is called specular reflection. Reflection from a rough surface causes scattering this is called diffuse reflection.  The colour of an opaque object is determined by which wavelengths of light are more strongly reflected. Wavelengths not reflected are absorbed. If all wavelengths are reflected equally the object appears white. If all wavelengths are absorbed the objects appears black.  Objects that transmit light are either transparent or translucent. | 1 | Explain how the colour an object looks depends on the absorption, transmission and reflection of different wavelengths of light.  Explain what dispersion is.  Draw rays diagrams to illustrate specular reflection by a smooth surface and scattering of light by a rough surface.  Explain how the colour of an opaque object is related to the wavelengths of light that are reflected and the wavelengths of light that are absorbed.  Explain why a red jacket appears red under white light or red light and black under blue light  Explain why objects appear black when placed under a light source.  Define transparent and translucent. | Investigate the colours that make up white light using a triangular prism. Make a Newtons wheel and then spin it very fast by putting it on the end of a drill. Demonstrate how the colour white can be made up from the three primary colours. This can be done with a spinning top with coloured card attached and spun quickly.  Research the wavelengths and frequencies of the seven colours and how the wavelength, speed and frequency changes when the light passes from air into glass or Perspex.  Investigate the law of reflection using mirrors. Is the angle of incidence equal to the angle of reflection? What were the limitations of your investigation?  Investigate how the colour of an object varies according to the colour of light incident upon it using filters to help.  Investigate transparent and translucent objects and their effect on light. | [TED talk on how we see colour](http://ed.ted.com/lessons/how-we-see-color-colm-kelleher)  [Cyber Physics: The physics of colour](http://www.cyberphysics.co.uk/topics/light/color.htm)  Reflection of light from smooth and rough surfaces: [Specular vs. diffuse reflection](http://www.physicsclassroom.com/class/refln/Lesson-1/Specular-vs-Diffuse-Reflection)  Mixing light:  [Mixing coloured light](https://www.youtube.com/watch?v=4hem_RTs780)  MWB Q&A based on teacher’s questions |

### 4.6.3 Black body radiation (physics only)

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop scientific communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.3.1 | Emission and absorption of infra-red radiation.. | All objects, no matter what temperature, emit and absorb infra-red radiation. The hotter an object is the more infra-red radiation it radiates in a given time. | 1 | Describe and explain the factors that affect the rate of cooling of an object.  Explain how the rate of cooling of a black object depends on the temperature that the object is at. | Why does a black car get hotter than a white car in the summer?  Investigate the rate of cooling by measuring 200 ml of boiling water and taking the temperature every 30 seconds using a temperature sensor. Plot a graph of temperature against time.  Use a Lesley cube to investigate the emission of infra-red radiation by objects of different colour. Opportunity to use data loggers and temperature sensors attached to each of the four sides of the Leslie Cube. | [BBC Bitesize – Energy transfer by heating](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/heatingrev1.shtml)  [Heat radiation – Infrared radiation](http://www.cyberphysics.co.uk/topics/heat/radiation.htm)  [Heat (thermal) energy and heat transfer](http://www.passmyexams.co.uk/GCSE/physics/radiation-heat-transfer.html)  GCSE Boardworks – Heat Transfer sections  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.3.1 | Black body radiation. | A perfect black body is an object that absorbs the entire radiation incident on it. The object does not reflect or transmit any radiation. Since a good absorber is also a good emitter a perfect black body would be the best possible emitter. | 1 | Define what is meant by a black body in terms of radiation.  Describe and explain why black would be a good colour for a central heating radiator and suggest why most radiators are painted white.  Explain what is meant by black body radiation. | Why do schools have black T-shirts when they are much hotter in the summer?  Plan an experiment to see if black T-shirts would keep you cooler in the summer than white T-shirts.  Alternatively plan and investigate whether a black or silver can keeps water hotter for longer. | [Perfect black body and its spectrum](https://www.youtube.com/watch?v=IQvJ4gHs_sg)  GCSE Boardworks – Heat Transfer sections  MWB Q&A session based around activities listed on Boardworks and/ or teacher’s own questions. |
| 4.6.3.2 | The emission of infra-red radiation by objects with different temperatures.  Thermal equilibrium. HT only.  Absorption of radiation by the Earth’s atmosphere. HT only. | All objects emit radiation. The intensity and wavelength distribution of any emission depends on the temperature of the object. When the temperature is increased the intensity of every wavelength of radiation emitted increases but the intensity of the shorter wavelengths increases more rapidly making the object appear more white.  An object at constant temperature is absorbing radiation at the same rate as it is emitting radiation. The temperature of an object increases when the object absorbs radiation faster than it emits radiation. HT only.  The temperature of the Earth depends on many factors including; the rates of absorption and emission of radiation, reflection of radiation into space. HT only. | 1 | Explain how the colour of an object is linked to the temperature of that object in terms of intensity of wavelengths emitted.  Explain why an object in thermal equilibrium must be absorbing and emitting radiation at the same rate.  Draw/ interpret diagrams to show how radiation affects the temperature of the Earth’s surface and atmosphere. | Why do very hot objects appear white?  Research to find out how the wavelength of radiation emitted by an object changes with temperature.  The investigation detailed above in section ‘Emission of infra-red radiation by hot objects’ could be carried out until it reaches thermal equilibrium. Or conduct the investigation outlined in the following video on [Thermal equilibrium](https://www.youtube.com/watch?v=vcgYQ-u7qfc).  Research how the Earth’s atmosphere absorbs emits and reflects radiation. Find out how different gases in the atmosphere affect the rate of absorption, emission and reflection of radiation. | [Reducing heat transfers – the human body](http://www.bbc.co.uk/education/guides/zttrd2p/revision/5)  Pupils respond to their research.  Thermal equilibrium:  [What is the second law of thermodynamics?](http://animatedscience.co.uk/blog/category/as/unit5)  MWB Q&A based on teacher’s questions.  Atmospheric effects on  [Atmospheric effects on incoming solar radiation](http://www.physicalgeography.net/fundamentals/7f.html)  [Teachers TV: Climate change – the causes](https://www.youtube.com/watch?v=RHrFBOUl6-8)  [Video: The greenhouse effect](https://www.youtube.com/watch?v=5zLuqSYF68E)  [Cyber Physics: Global warming](http://www.cyberphysics.co.uk/topics/energy/global_warming.htm) |