Unit 9: Waves

Recommended prior knowledge
Although the Cambridge IGCSE Physics course may be an introduction to Physics, it is probable that most students will have been taught some Physics or General Science already. Both sound and light are phenomena that all students will be aware of and will have realised that they can be understood and investigated as branches of science.

Students might well be aware that waves can be used to transfer energy from one location to another and might well have been given basic definitions of wave motion. It is less likely that they will have encountered the distinction between oscillations of matter being used to transfer energy as a wave and the actual movement of matter with energy with it; this might be highlighted at this stage. Students might well be aware of simple sound phenomena and will probably know words such as *pitch* and *loudness*. They will have seen demonstrations that show the need for a medium to transmit sound and might well know that sound travels differently in different media; different speeds and different attenuation rates. They are also likely to be aware that whilst the speed of sound is large, it is very substantially less than that of light. Similarly, a student might be aware that sound spreads out in a way that light doesn't although the precise nature of diffraction is unlikely to be understood.

Students will have heard of infra-red radiation (and perhaps ultraviolet radiation – although this is not separately mentioned in the syllabus) but will not necessarily follow what is meant by the phrase *invisible light* which is often applied to this component of the electromagnetic spectrum. Likewise ultrasound might have been described *as sound which we cannot hear*.

Context
Within the Cambridge IGCSE Physics course, *Waves, sound and light* are natural partners and can be dealt with early on in the course; there are few challenging concepts although some students will struggle with the idea of frequency. It is also likely that there will be those who cannot invariably rearrange $v = f\lambda$ and obtain the correct answer. Inevitably, the study of infra-red radiation will link in with the study of the transfer of thermal energy and it might help if the electromagnetic spectrum could be studied before thermal transfer. Otherwise, the term *radiation* (used in many different ways in physics and frequently confused in the media) and can easily lead to misunderstanding. Waves are often represented in diagrammatic forms and this unit can be used to emphasise the importance of clear and appropriate diagrams in explaining the subject both generally and in answering examination questions.

Outline
This unit contains ideas that relate to the common experiences of many students and it can be used to show that everyday phenomena can be more thoroughly understood when a scientific explanation is offered.

(Please note: **(S)** in **bold** denotes material in the Supplement (Extended syllabus) only)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3.1	Describe what is meant by wave motion as illustrated by vibration in ropes, springs and by experiments using water waves Use the term wavefront Give the meaning of speed, frequency, wavelength and amplitude Distinguish between transverse and longitudinal waves and give suitable examples Describe the use of water waves to show - reflection at a plane surface - refraction due to a change of speed - diffraction produced by wide and narrow gaps	Begin with waves on ropes and a 'slinky' spring to illustrate transverse and longitudinal waves. A ripple tank can then be used to show reflection, refraction and diffraction of water waves. Sound undergoes diffraction easily but light needs special apparatus to show this property. Use 3 cm (micro)wave equipment to illustrate reflection, refraction (beeswax blocks or Perspex cubes filled with paraffin) and diffraction. A narrower slit can actually increase the intensity at some off-centre positions as the weaker signal reaches places that the stronger one (wider slit) did not diffract to.	This website has clear demonstrations of transverse and longitudinal waves: www.members.aol.com/nicholashl/waves/movingwaves.html IGCSE Physics Coursebook CD-ROM Activity Sheet 14.1 Unit 9: Past Paper Question Core 1 and 3 Unit 9: Past Paper Question Extension 2
3.1 (S)	**Recall and use the equation $v = f\lambda$** **Interpret reflection, refraction and diffraction using wave theory**	**Find the wavelengths and frequencies for local radio stations and calculate *c*.** **Use a set of ripple tank projection slides to reinforce the ripple tank work and focus on more detailed discussion.**	www.hyperphysics.phy-astr.gsu.edu/hbase/wavrel.html www.gcse.com/waves/vfl.htm

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3.2 (e)	Describe the main features of the electromagnetic spectrum and state that all e.m. waves travel with the same high speed *in vacuo* Describe the role of electromagnetic waves in: - radio and television communications (radio waves) - satellite television and telephones (microwaves) - electrical appliances, remote controllers for televisions and intruder alarms (infra-red) - medicine and security (X-rays) Demonstrate an awareness of safety issues regarding the use of microwaves and X-rays	Include plenty of examples to show students that they already have much general knowledge regarding the uses of electromagnetic waves. Quote frequency and wavelength values and show that as f increases, λ decreases. Identify the radio wave, microwave, infra-red and X-ray regions of the e.m. spectrum. Explain that the first three can be encoded with digital or analogue signals to transmit messages remotely. Explain that X-rays can be used both diagnostically and therapeutically in medicine and discuss the risks of using and of not using X-rays in medicine. Discuss the likely dangers of using mobile phones and problems that arise when microwaves escape from faulty microwave ovens.	www.schooltube.com/video/6ea0d020a582f8d6b1c1/The-Electromagnetic-Spectrum www.youtube.com/watch?v=UzI1z0u_700 www.vimeo.com/16996376 Unit 9: Past Paper Question Core 2
3.2 (e) (S)	**State the approximate value of the speed of electromagnetic waves** **Use the term monochromatic**	**There is no particular reason for not quoting the exact (to 2 sig. figs) value 3.0 × 10^8 m/s here.** **Calculate how long it takes for an intercontinental phone call to travel to a satellite (height ~35 000 km) and back and then for the reply to make the same journey.**	Good presentation of electromagnetic waves showing the link between wavelength and uses: www.colorado.edu/physics/2000/index.pl click on Science Trek click on Electromagnetic Waves

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3.3	Describe the production of sound by vibrating sources Describe the longitudinal nature of sound waves State the approximate range of audible frequencies Show an understanding that a medium is required in order to transmit sound wavesDescribe an experiment to determine the speed of sound in air Relate the loudness and pitch of sound waves to amplitude and frequency Describe how the reflection of sound may produce an echo	Use a variety of musical instruments/vibrating rulers/pieces of card in the spokes of a bicycle wheel etc. to introduce this section. A signal generator and loudspeaker can be used to investigate the range of audible frequencies.(the usual range is considered to be ~20 Hz to ~ 20 kHz. Few teachers will hear frequencies as high as most of their students and the upper limit is reduced as one get older. A bell in a bell jar that can be evacuated can be used to show that a medium is required for the transmission of sound (at the same time showing that light travels through a vacuum). Sound can still pass through the structure holding the bell in place. Use of a c.r.o. and microphone gives a visual picture of amplitude and frequency. Extension candidates can analyse the c.r.o. traces in more detail.	This website contains much interesting work on resonance including a video of the Tacoma Narrows Bridge disaster: www.enm.bris.ac.uk/ This website about sound waves is informative and includes audio: www.youtube.com/watch?v=usHtqr0_HXU IGCSE Physics Coursebook CD-ROM Activity Sheet 12.1, 12.2
3.3 (S)	**Describe compression and rarefaction** **State the order of magnitude of the speed of sound in air, liquids and solids**	**A large-scale, outdoor echo method to determine the speed of sound in air can be used.** **Where a long metal fence is near by, it is possible to strike it with a hammer and for a distant observer to hear the sound twice: once through the air, once through the fence.**	www.youtube.com/watch?v=HlSCwV8d5qM Unit 9: Past Paper Question Extension 1