THE SOUND OF MUSIC

Overview of chapter

Table 2.1 summarises the content and skills covered in this chapter, and Table 2.2 lists the learning outcomes required by the exam specification. The latter are also listed as 'Achievements' in the final section of the chapter in the Student Book.

Table 2.1 Summary of the chapter *The Sound of Music*

Outline and reference to student materials			Key points	Skills	Notes
Section 1.1 Synthetic sounds	Comparing 'real' and synthesised sounds	Activity 1		Communication	
Section 1.2 Oscillations	Measuring period and frequency	Activity 2 Additional Sheet 1	Frequency, period, amplitude	Application of number Practical work Study skills/ communication	GCSE revision
	Using graphs and oscilloscope to visualise oscillations	Activity 3	Shape of graph related to audible characteristics of sound	Application of number Practical work Study skills/ communication	
	Using software to display oscillations	Activity 4 Additional Sheet 2	Shape of graph related to audible characteristics of sound	Use of ICT Study skills/ communication	Idea of waveforms is revisited in later sections of Part 1
	Discussion of graphical representations		Idea of phase, phase difference Radians	Application of number	
Section 1.3 Travelling waves	Observing transverse and longitudinal waves	Activity 5	Displacement Wavefronts Compressions and rarefactions	Practical work Communication	GCSE revision
Section 1.4 Graphs of travelling waves	Using graphs to represent transverse travelling waves	Activity 6 Additional Sheet 3	Displacement–time and displacement–position graphs The wave equation	Application of number	GCSE revision
	Using graphs to explore pressure and displacement in sound waves	Activity 7	Pressure and displacement are not in phase	Application of number	
	Using speaker, microphone and oscilloscope to find the speed of sound	Activity 8	Relationship between phase difference and time difference	Practical work	Core practical

Outline and reference to student materials			Key points	Skills	Notes
Section 1.5 Superposition and standing waves	Using software to combine waves	Activity 9	Idea of superposition Coherence Phase and path difference	Use of ICT	Superposition is revisited in Sections 3.2 and 4.2
	Observing standing waves produced by reflection Using graphs to explore the generation of standing waves	Activity 10	Phase change on reflection at a 'hard' boundary	Practical work Application of number	
Section 1.6 Summing up Part 1	Using diagrams and words to summarise key points	Activity 11	Application of skills and knowledge from Part 1	Study skills	
Section 2.1 Stringed instruments	Reading about generation of notes in stringed instruments	Additional Sheet 5	Introducing ideas about standing waves; nodes and antinodes		
	Exploration of factors affecting note from a string	Activity 12 Additional Sheets 2 and 4	Speed of waves on string: mass, length and tension	Practical work	Core practical
Section 2.2 Wind instruments	Reading about generation of notes in wind instruments	Activity 13 Additional Sheet 6	Positions of displacement and pressure nodes for open and closed pipes Idea of resonance	Communication	Resonance is treated in more detail in *Build or Bust?*
	Using a recorder and software to measure sound speed	Activity 14 Additional Sheets 2 and 4	Speed of sound in air	Use of ICT Practical work	
Section 2.3 Quality or timbre	Using software to display and explore complex sounds	Activity 15 Additional Sheets 2, 4 and 7	Idea of frequency spectrum Sampling	Use of ICT	
Section 2.4 Summing up Part 2	Use of key ideas from Part 2 Using software to explore synthesised sounds	Activity 16 Additional Sheets 2 and 4	Application of knowledge and skills from Part 2	Study skills Communication Use of ICT	
Section 3.1 What's on the discs?	Examining and listening to CD and LP Reading about CD technology	Activity 17 Activity 18 Additional Sheet 7	Idea of digital signal	Communication	Some GCSE revision
Section 3.2 Optical scanning	Explaining and demonstrating how superposition of reflected waves can give on–off signal	Activity 19 Additional Sheets 1 and 3	Phase, coherence, path difference and superposition	Application of number	Connects with Section 1.5
Section 3.3 Summing up Part 3	Summary of key points	Activity 20	Application of knowledge and skills from Part 3	Communication Study skills	
Section 4.1 Laser	Laser	Activity 21	Photon model of electromagnetic radiation Idea of energy levels	Practical work Application of number	
	Observing and explaining laser action	Activity 22	Idea of stimulated emission Coherent radiation		

Outline and reference to student materials			Key points	Skills	Notes
Section 4.2 Summing up Part 4	Use of key ideas from Part 4 to explain the operation of a CD player	Activity 23 Activity 24	Application of skills and knowledge from Part 5	Study skills Communication	
Section 5.1 Waves	Summarising aspects of wave behaviour	Activity 25 Additional Sheet 8		Study skills	
Section 5.2 Questions on the whole chapter	Questions and calculations	Additional Sheet 9		Communication Application of number	Consolidation and revision
Section 5.3 Achievements	Chapter test	Additional Sheets 10 and 11		Communication Application of number	Questions illustrate style of external test

Table 2.2 Learning outcomes specified for *The Sound of Music*

Statement from Examination Specification		Section(s) in this chapter
1	know and understand the distinction between base and derived quantities and their SI units	1.2, 2.1
2	demonstrate their knowledge of practical skills and techniques for both familiar and unfamiliar experiments	1.2, 1.4, 2.1, 2.2
5	be able to communicate information and ideas in appropriate ways using appropriate terminology	2.2, 3.1, 3.2, 4.2
59	understand the terms *amplitude*, *frequency*, *period*, *speed* and *wavelength*	1.2, 1.4, 3.2
60	be able to use the wave equation $v = f\lambda$	1.4, 3.2
61	be able to describe longitudinal waves in terms of pressure variation and the displacement of molecules	1.3, 1.4
62	be able to describe transverse waves	1.4
63	be able to draw and interpret graphs representing transverse and longitudinal waves including standing/stationary waves	1.4, 1.5
64	CORE PRACTICAL 6: Determine the speed of sound in air using a two-beam oscilloscope, signal generator, speaker and microphone	1.4
65	know and understand what is meant by *wavefront*, *coherence*, *path difference*, *superposition*, *interference* and *phase*	1.5, 2.1, 2.2, 3.2
66	be able to use the relationship between phase difference and path difference	1.3, 3.2
67	know what is meant by a *standing*/*stationary wave*, and understand how such a wave is formed, know how to identify nodes and antinodes	1.5, 2.1, 2.2
68	be able to use the equation for the speed of a transverse wave on a string: $v = \sqrt{\frac{T}{\mu}}$	2.1
69	CORE PRACTICAL 7: Investigate the effects of length, tension and mass per unit length on the frequency of a vibrating string or wire	2.1
90	understand how the behaviour of electromagnetic radiation can be described in terms of a wave model and a photon model, and how these models developed over time	3.2, 4.1
91	be able to use the equation $E = hf$ that relates the photon energy to the wave frequency	4.1
95	understand atomic line spectra in terms of transitions between discrete energy levels and understand how to calculate the frequency of radiation that could be emitted or absorbed in a transition between energy levels	4.1

This chapter uses the context of music to introduce some work on waves and light. It could be taught before, after or in parallel with the chapter *Good Enough to Eat*, which includes other aspects of the behaviour of light (refraction and polarisation). It is intended that *The Sound of Music* should be completed before teaching the more advanced material (photoelectric effect) in *Technology in Space*.

This chapter involves some GCSE revision as well as new material. If you are confident that your students already have a firm grasp of waves at GCSE level, it would be wise to spend only a short time on the revision activities or omit them altogether. However, going over familiar ground can be valuable, particularly in activities that help develop students' skills in using ICT, working with others and introducing rigour in defining key terms.

Parts 1 and 2 use music and musical sounds to explore some ideas about the physics of waves and sound, in particular the problem of analysing and reconstructing sounds. Parts 3 and 4 describe the operation of the CD player and some of the wave/particle properties of light. Throughout all parts, there is an emphasis on using graphs and diagrams to represent physical phenomena and to record results and observations.

Parts 1 and 2 could be taught in parallel with Parts 3 and 4 by two different teachers. As well as basic ideas about waves, the ideas of phase and superposition are needed in the treatment of musical instruments and of the CD player, so some liaison between teachers is desirable.

Part 5 looks back over the whole chapter and helps students to draw together the physics from all parts. In particular, students summarise, compare and contrast the various types of wave that they have studied. You may want to spend some time at the end ensuring that your students can generalise the new concepts away from the specific context presented here.

Software

Much of Parts 1 and 2 of this chapter is based on *Audacity* – a piece of free open-source software for recording and editing sounds. The web address is given at www.pearsonhotlinks.co.uk (search for this title).

It includes 'Analysis', which has the following features.

- a spectrogram mode for visualising frequencies
- a 'Plot Spectrum' command for detailed frequency analysis.

If students are using this software on their own PCs outside lessons, it is worth making sure that they all use the same version, as the interface can vary markedly.

There are also a number of useful apps and e-books for smartphones and tablets, some of which are suggested in the Student Book.

Fourier analysis and synthesis

Parts 1 and 2 of the chapter help students to develop a thorough understanding of wave terminology and phenomena, such as superposition. While no attempt is made to discuss Fourier analysis with students, it may be helpful for the teacher to be familiar with the basic idea. In essence, the principle of Fourier analysis and synthesis is that any periodic waveform, no matter how complex, can be represented as the summation of a series of sinusoidal components. The frequencies of the components are multiples of the frequency of the original. For example, you can synthesise a 'square wave' function $f(x)$:

$$f(x) = \cos(x) + \tfrac{1}{3}\cos(3x) + \tfrac{1}{5}\cos(5x) + \tfrac{1}{7}\cos(7x) + \ldots$$