

## 12.2 Wave model (full C.2)

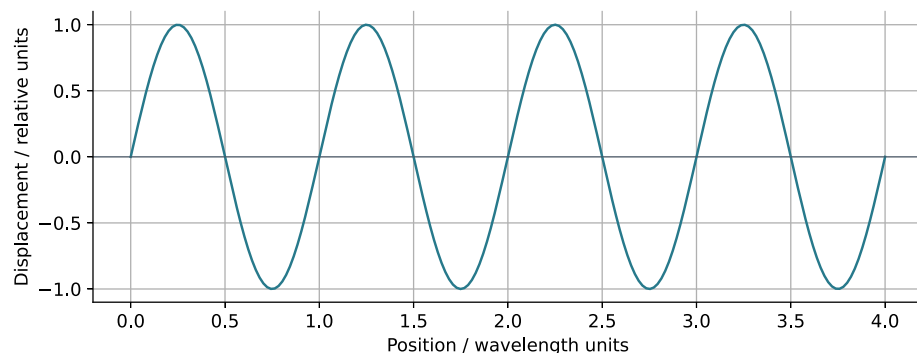
Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 24 marks**

**KEY WORDS** transverse wave • longitudinal wave • electromagnetic wave  
• wavelength

### Objective

Practise the full guide C.2 toolkit: transverse and longitudinal travelling waves described by displacement against position and against time,  $v = f\lambda = \lambda/T$ , the nature of sound and electromagnetic waves, mechanical-versus-electromagnetic differences, and medium changes at fixed frequency. Original practice; not an official IB paper.

### 1 Key knowledge and worked examples



#### ■ The C.2 equation set

$$v = f\lambda = \frac{\lambda}{T}$$

Transverse: oscillations across the propagation direction (rope, all electromagnetic waves). Longitudinal: oscillations along it, as compressions and rarefactions (sound). Sound is mechanical – it needs a medium; electromagnetic waves are transverse field oscillations that cross a vacuum at  $c = 3.0 \times 10^8$  m/s.

#### ■ Worked example: reading a wave two ways

A wave of frequency 2.0 Hz slows from 0.60 m/s to 0.40 m/s entering shallow water. Deep:  $\lambda = v/f = 0.60/2.0 = 0.30$  m. Shallow: frequency is fixed by the source, so  $\lambda = 0.40/2.0 = 0.20$  m. A snapshot graphs displacement against position and shows this wavelength; a recorder at one fixed point graphs displacement against time and shows the period  $T = 0.50$  s. Two habits: name which pair of variables a graph connects before reading it, and change only what the medium controls.

### 2 Practice

**2.1** Distinguish between transverse and longitudinal waves, giving one example of each.[2]

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**2.2** A travelling wave has wavelength 0.25 m and frequency 8.0 Hz. Calculate its speed.[2]

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**2.3** State two differences between sound waves and electromagnetic waves. [2]

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**2.4** A water wave passes into a region where it travels more slowly. State what happens to its frequency, speed and wavelength. [2]

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### 3 Exam-style questions

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**3.1** A note of frequency 440 Hz travels through air at 340 m/s. Calculate the wavelength and the period, and state whether doubling the amplitude of oscillation changes the wave speed. [4]

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**3.2** A microwave oven emits radiation at 2.45 GHz. Calculate the wavelength, name the position of microwaves in the electromagnetic spectrum, and explain why this radiation can cross a vacuum while sound cannot. [4]

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**3.3** A transverse wave of period 0.50 s is travelling through a rope. Describe what a graph of displacement against time at one fixed point on the rope shows, and describe how particle motion differs in a longitudinal wave. [4]

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**3.4** A water wave of frequency 2.0 Hz travels at 0.60 m/s in deep water and 0.40 m/s in shallow water. Calculate the wavelength in each region, and explain which quantity stays fixed and why. [4]

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## Solutions

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Original-task marking: M1 method, A1 accuracy, B1 reasoning.

**2.1** Transverse: particle oscillations perpendicular to the direction of energy transfer, e.g. waves on a rope; longitudinal: oscillations parallel to it, as compressions and rarefactions, e.g. sound.

**2.2**  $v = f\lambda = 8.0 \times 0.25 = 2.0 \text{ m/s}$ .

**2.3** Any two: sound is longitudinal, electromagnetic waves are transverse; sound is mechanical and needs a medium, electromagnetic waves cross a vacuum; sound travels far slower – about 340 m/s in air against  $3.0 \times 10^8 \text{ m/s}$  for light; sound is a disturbance of matter, electromagnetic waves are oscillating fields.

**2.4** Speed decreases and wavelength decreases; frequency is unchanged.

**3.1**  $\lambda = v/f = 340/440 = 0.77 \text{ m}$ ;  $T = 1/f = 2.3 \times 10^{-3} \text{ s}$ ; amplitude sets loudness, not speed – speed is fixed by the medium.

**3.2**  $\lambda = c/f = (3.0 \times 10^8)/(2.45 \times 10^9) = 0.12 \text{ m}$ ; microwaves sit between radio and infrared; electromagnetic waves are oscillating electric and magnetic fields that need no medium, while sound is a mechanical vibration of matter.

**3.3** A sinusoid of period 0.50 s repeating each cycle – the particle oscillates up and down about equilibrium in simple harmonic fashion; in a longitudinal wave the particles oscillate parallel to the propagation direction, so displacements appear as compressions and rarefactions rather than crests and troughs.

**3.4** Deep:  $\lambda = 0.60/2.0 = 0.30 \text{ m}$ ; shallow:  $\lambda = 0.40/2.0 = 0.20 \text{ m}$ ; frequency stays fixed because it is set by the source – the medium controls speed, and wavelength follows.