

Exercise walk-through

# 12.2

## Wave model (full C.2)

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International Baccalaureate · IB Diploma · Physics · HL

# Waves · 3.1

## Reasoning

At a boundary, frequency stays fixed by the source. A change of speed changes wavelength. Refraction follows from speed differences; angles are measured from the normal. Measure several wavelengths and divide to reduce fractional reading uncertainty. Use a ray box with a normal drawn at the boundary. Keep the beam away from eyes and record incident and refracted angles clearly.

## Frequency across a boundary

- 1 Set the model** A water wave has frequency 2.0 Hz. It slows from 0.60 to 0.40 m/s in shallower water.
- 2 Calculate** Before:  $\lambda = v/f = 0.30$  m. After:  $\lambda = 0.40/2.0 = 0.20$  m.

### Decision

The source fixes frequency. Changing wave speed changes wavelength; the particles do not travel with the wave profile.

## Exercises 2.1·2.3

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**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]

## Exercises 2.1-2.3

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

**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.

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

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

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

**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.

## Exercises 2.4·3.2

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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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**3.1** 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]

## Exercises 2.4·3.2

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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]

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

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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]

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

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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]

**3.2**  $\lambda = c/f = (3.0 \times 10^8)/(2.45 \times 10^9) = 0.12$  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.

## Exercises 3.3-3.4

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**3.3** A transverse wave of period  $0.50\text{ s}$  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  $2.0\text{ Hz}$  travels at  $0.60\text{ m/s}$  in deep water and  $0.40\text{ m/s}$  in shallow water. Calculate the wavelength in each region, and explain which quantity stays fixed and why. [4]

## Exercises 3.3-3.4

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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]

**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.

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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]

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