INTERNATIONAL BACCALAUREATE · IB DIPLOMA · PHYSICS · SL • EXERCISE SHEET

9.2 Wave model (full C.2)

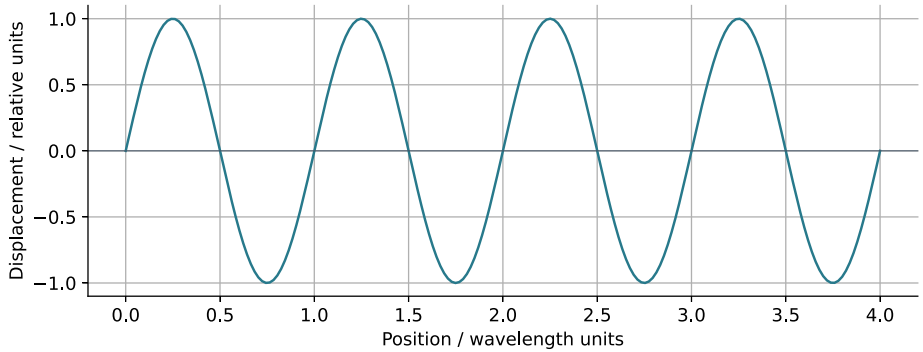
Name: _____ Class: _____ Date: _____ **Total: 24 marks**

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]

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

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

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

3 Exam-style questions

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]

3.2 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]

3.3 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]

3.4 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]

Solutions

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 $v = f\lambda = 8.0 \times 0.25 = 2.0$ 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 3.0×10^8 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 $\lambda = v/f = 340/440 = 0.77$ m; $T = 1/f = 2.3 \times 10^{-3}$ s; amplitude sets loudness, not speed – speed is fixed by the medium.

3.2 $\lambda = c/f = (3.0 \times 10^8)/(2.45 \times 10^9) = 0.12$ 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: $\lambda = 0.60/2.0 = 0.30$ 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.