6.1 Transverse, longitudinal waves and the wave equation

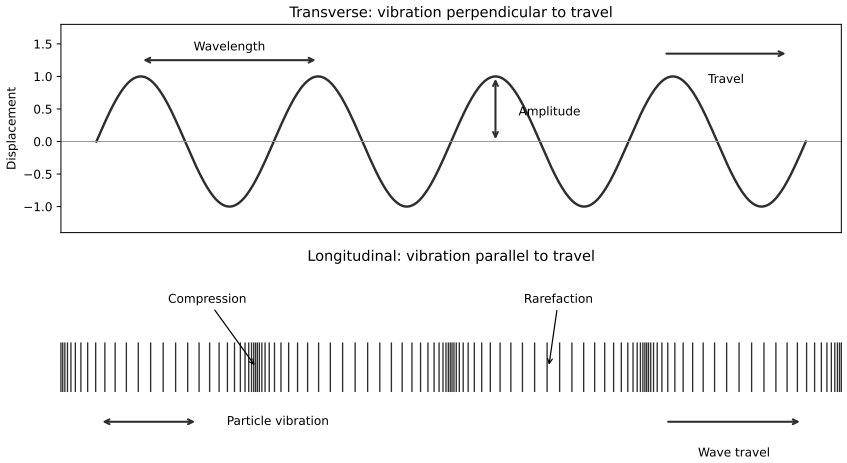
Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS transverse • longitudinal • compressions • rarefactions • amplitude • wavelength • frequency • period

Objective

Distinguish transverse from longitudinal waves, use amplitude/wavelength/frequency/period language, and apply $T = 1/f$ and $v = f\lambda$ with prefixes. Original questions for spec statements 4.6.1.1–4.6.1.2 and RP8.

1 Key knowledge and worked examples



Transverse vibrates across; longitudinal along.

Type	Vibration direction	Examples
transverse	across the travel direction	water ripples, all EM waves
longitudinal	along the travel direction	sound in air

Energy travels with the wave; particles oscillate about equilibrium with no net transport of the medium in this model. A floating ball bobs while a ripple passes.

Quantity	Meaning
amplitude	maximum displacement from the undisturbed position
wavelength	point on one wave to the equivalent point on the next
frequency	waves passing a point each second, Hz
period	time for one wave

$$T = \frac{1}{f} \qquad v = f\lambda$$

Wave speed is the speed of **energy transfer** through the medium.

Worked example. Sound of frequency 4.0 kHz travels at 330 m/s.

- Convert: $f = 4000$ Hz.

$$\lambda = \frac{v}{f} = \frac{330}{4000} = 8.3 \times 10^{-2} \text{ m (2 s.f.)}$$

RP8: use a calibrated scale at the water surface and divide a distance across several crest-to-crest intervals by the number of intervals; correct any projected measurement for magnification. Time N complete cycles: $f = N/t$. For n stationary string loops over length L, $\lambda = 2L/n$; read f from the generator. For an echo from a wall distance d away, $v = 2d/t$; repeat and use electronic timing.

2 Practice

2.1 A wave has frequency 250 Hz. Calculate the period. [2]

2.2 Water waves of wavelength 0.25 m travel at 1.5 m/s. Calculate the frequency. [2]

2.3 State one piece of evidence that in a water ripple it is the wave, not the water, that travels. [1]

3 Exam-style questions

3.1 A teacher times 10 complete cycles passing a point in a ripple tank: 12.0 s in total. The wavelength at the water surface, measured with a calibrated scale, is 0.080 m.

(a) Calculate the frequency. [2]

(b) Calculate the speed of the water waves. [2]

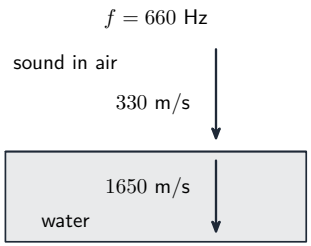
(c) The bar motor speeds up. State and explain the effect on wavelength at constant wave speed. [2]

3.2 Sound from a stationary source crosses a stationary boundary from air into water, where it moves faster.

(a) State which of frequency and wavelength changes, and why frequency cannot. [2]

(b) The speed rises from 330 m/s to 1650 m/s at an unchanged frequency of 660 Hz. Calculate both wavelengths. [3]

(c) Describe how the wavefront spacing looks in a diagram after entering the water. [1]



Solutions

2.1 $T = 1/f = 1/250 = \mathbf{4.0 \times 10^{-3}}$ s (C1, A1)

2.2 $f = v/\lambda = 1.5/0.25 = \mathbf{6.0}$ Hz (C1, A1)

2.3 A floating ball bobs up and down but does not travel with the ripple.

3.1 (a) $f = N/t = 10/12.0 = \mathbf{0.83}$ Hz (2 s.f.) (C1, A1) (b) $v = f\lambda = 0.833 \times 0.080 = \mathbf{0.067}$ m/s (C1, A1) (c) Wavelength decreases: $\lambda = v/f$ – the question specifies constant speed, so a higher frequency forces a shorter wavelength.

3.2 (a) Wavelength changes; frequency does not – the number of wavefronts arriving per second cannot change at the boundary. (b) Air: $\lambda = v/f = 330/660 = \mathbf{0.50}$ m (C1); water: $\lambda = v/f = 1650/660 = \mathbf{2.5}$ m; five times longer, matching the speed ratio. (c) The wavefronts are drawn further apart.