12.1 Waves, measurement and refraction

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS frequency • wavelength

Objective

Waves, measurement and refraction. Original classroom practice for IB HL; not an official IB paper.

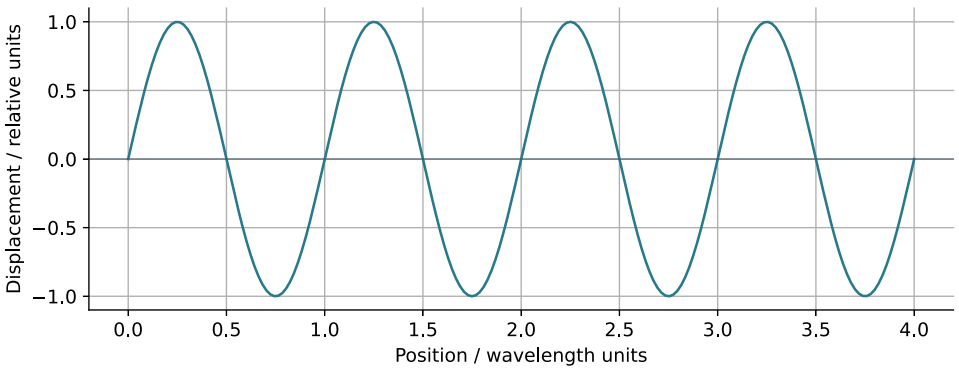
1 Key knowledge and worked examples

■ What would explain this observation?

- A wave can carry energy across water while a floating marker mainly oscillates. Energy transfer and bulk transfer of matter are different.

■ Build the model

- **Frequency** is oscillations per time; **wavelength** is distance between successive points in phase.
- Wave speed equals frequency multiplied by wavelength.
- Transverse oscillations are perpendicular to propagation.
- wavelength: Distance between successive points in phase.
- frequency: Number of oscillations per unit time.



■ Choose evidence that can test it

- 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.

In the lab: 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.

■ Work from known quantities

- Known: frequency 5 Hz and wavelength 0.40 m.
- Use $v = f\lambda$. $v = 5\times0.40 = 2.0$ metres per second.
- If speed falls to 1.5 metres per second at the same frequency, wavelength $= v/f = 1.5/5 = 0.30$ m.

Your turn: Frequency is 8 Hz and wavelength is 0.25 m. Find wave speed.

■ Check the conclusion and its limits

- The wave frequency does not change simply because the medium changes.
- A longitudinal wave has oscillations parallel to propagation.

Not true: Wave frequency always changes when a wave enters a new medium. Frequency is fixed by the source, so it stays the same across a boundary. What changes is speed, and therefore wavelength through v = f x wavelength.

Key:

- Frequency is oscillations per time; wavelength is distance between successive points in phase.
- At a boundary, frequency stays fixed by the source.
- Watch for: the wave frequency does not change simply because the medium changes.

■ Write from a wave speed of 7.2 metres per second

- Frequency is 9 Hz and wavelength is 0.80 m.
- Find the wave speed. If the speed becomes 5.4 metres per second at a boundary, find the new wavelength. Frequency stays the same.

2 Practice

2.1 When a wave enters a slower medium, what stays constant? Choose one answer.

- **A** Frequency
- **B** Speed
- **C** Wavelength [1]

2.2 Frequency is 8 Hz and wavelength is 0.25 m. Find wave speed. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Wave frequency always changes when a wave enters a new medium. [2]

2.4 Distance between successive points in phase: write the technical term. [1]

3 Exam-style questions

3.1 A 5 Hz wave crosses a stationary boundary where speed falls from 2 to 1 m/s. Compare wavelengths and frequency. Explain the unchanged frequency. [4]

Solutions

2.1 A Frequency is set by the source and cannot change at the boundary - the waves arriving must equal the waves leaving. It is the speed that changes in a slower medium, and the wavelength adjusts because v = f x wavelength.

2.2 $v = f\lambda = 8 \times 0.25 = 2.0$ m/s.

2.3 False. Frequency is fixed by the source, so it stays the same across a boundary. What changes is speed, and therefore wavelength through v = f x wavelength.

2.4 wavelength. wavelength means Distance between successive points in phase.

3.1 Wavelengths are 0.40 and 0.20 m; frequency remains 5 Hz because the boundary is driven by the same source. Moving boundaries require a different analysis.