

Wave model

International Baccalaureate · IB Diploma · Physics · SL

Scope and prerequisites

This handout covers selected SL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

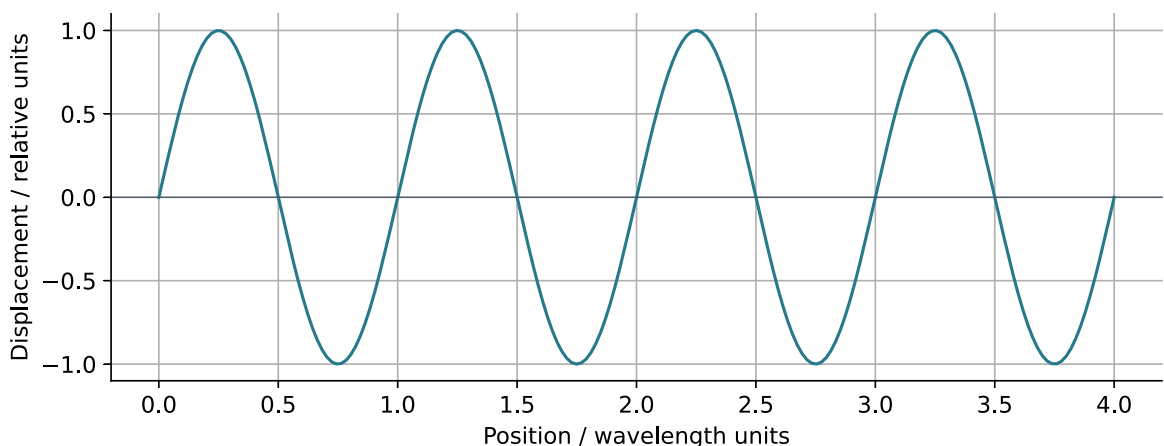
Waves, measurement and refraction

■ 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.
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■ 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.



One wavelength is the length of one complete cycle; $v = f\lambda$

■ 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 $v = f\lambda$. $v = 5 \times 0.40 = 2.0$ 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 $v = f \times \text{wavelength}$.

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 4.8 metres per second

- Frequency is 12 Hz and wavelength is 0.40 m.
- Find the wave speed. If the speed becomes 3.6 metres per second at a boundary, find the new wavelength. Frequency stays the same.

■ **Write from a time delay of 1.5 seconds**

- Lightning is seen; thunder arrives 1.5 s later (sound at 340 m s^{-1}).
- Distance = $340 \times 1.5 = 510 \text{ m}$ – light’s travel time is negligible at this scale, so the delay IS the sound’s travel time.

■ **Write from a boundary sentence**

- A wave passes into a slower medium.
- One sentence, four facts: frequency unchanged (set by the source), speed falls, wavelength shortens, the ray bends toward the normal.