Wave model

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL 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.

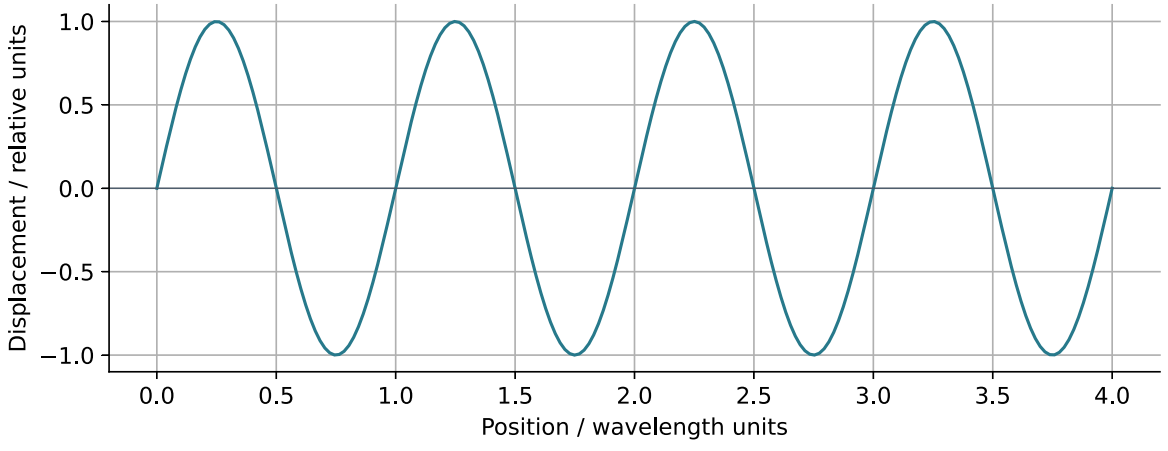
Waves, measurement and refraction

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.

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 = fλ. v = 5×0.40 = 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 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.

Write from a snell check

- Light passes from air into glass (n = 1.5) at 30° to the normal.
- sin θglass = sin 30° ÷ 1.5 = 0.333, so θglass ≈ 19.5° – toward the normal in the slower medium, as it must be.

Write from a critical angle

- Light travels from glass (n = 1.5) toward air.
- sin θc = 1 ÷ 1.5 = 0.667, so θc ≈ 41.8° – beyond it, total internal reflection: the fibre-optic condition.