Topic 3: Waves

Edexcel International GCSE Physics 4PH1 · Section 3 · statements 3.1–3.29P · sheets 3.1–3.2

Waves carry energy, not matter

Your turn

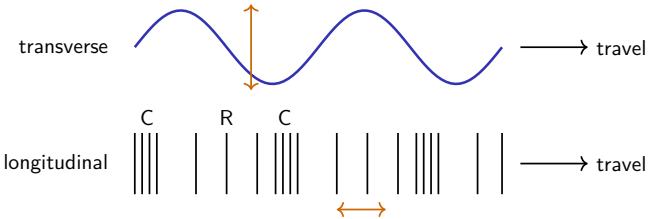
A cork bobs on a pond as ripples pass it.

A. Does the cork travel across the pond with the ripples?

B. What does the wave carry from one side to the other?

C. Name one wave that needs no medium at all.

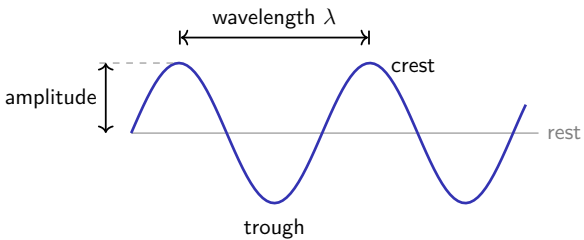
Transverse and longitudinal waves



Transverse: light and water waves. Longitudinal: sound, with compressions and rarefactions.

- Transverse: oscillation across the travel direction.
- Longitudinal: oscillation along it, compressions and rarefactions.

Amplitude, wavelength, frequency, period



Frequency is waves per second (Hz); the period is the time for one wave, $T = 1/f$.

- **Amplitude** is the maximum displacement from rest.
- Wavelength is crest to next crest.

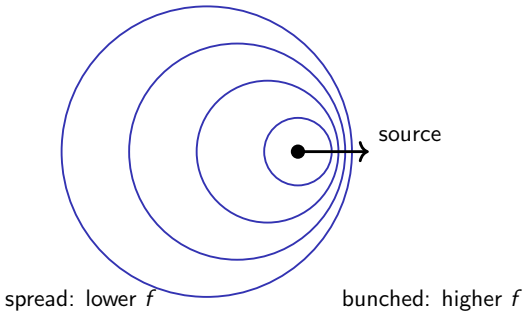
The wave equation

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

v in m/s, f in Hz, λ in m, T in s

1. **Known** Sound: $f = 340$ Hz, $v = 340$ m/s.
2. **Equation** $v = f\lambda$, so $\lambda = v/f$.
3. **Substitute** $\lambda = 340\ \mathrm{m/s} / 340\ \mathrm{Hz} = 1.0$ m.
4. **Period** $T = 1/f = 1/340\ \mathrm{Hz} = 0.0029$ s, about 2.9 ms.

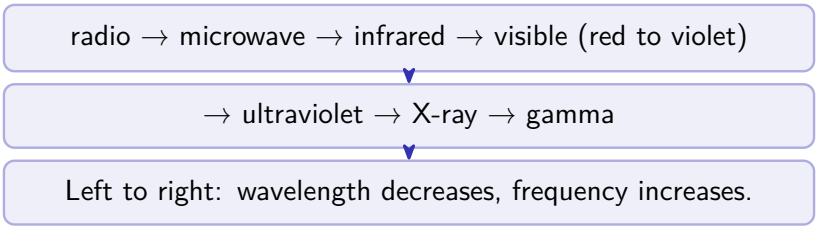
The Doppler effect



Towards the observer: shorter wavelength, higher frequency. Away: longer wavelength, lower frequency.

- Source moving towards you, wavefronts bunch up.
- Moving away, they spread out.

One family, ordered by wavelength



All electromagnetic waves are transverse and travel at the same speed in a vacuum.

Uses and dangers

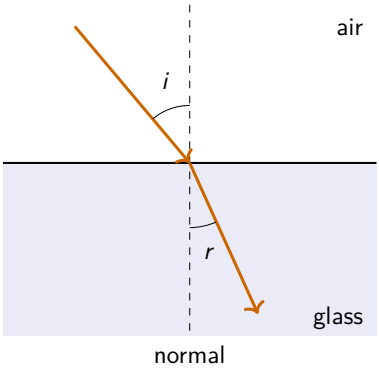
Radiation	Use	Danger
microwave	cooking, satellite TV	internal heating of tissue
infrared	heaters, night vision	skin burns
ultraviolet	fluorescent lamps	damages surface cells, eyes
X-ray	imaging inside bodies	cancer, mutation
gamma	sterilising equipment	cancer, mutation

Use the evidence

Radio: broadcasting. Visible: optical fibres. Protection: less time, shielding, sun cream.

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Reflection and refraction



Entering glass, light bends towards the normal; leaving, it bends away.

- Measure every angle from the normal.
- Into glass, light slows and bends towards the normal.

Snell's law: angles from the normal

$$n = \frac{\sin i}{\sin r} \qquad \sin c = \frac{1}{n}$$

i and r measured from the normal; c is the **critical angle**

1. **Known** $i = 50°$ in air, $r = 30°$ in the glass.
2. **Equation** $n = \sin i / \sin r$.
3. **Substitute** $n = \sin 50° / \sin 30° = 0.766 / 0.500 = 1.53$.
4. **Trap** A ray at 50° to the surface has $i = 40°$, not 50°.

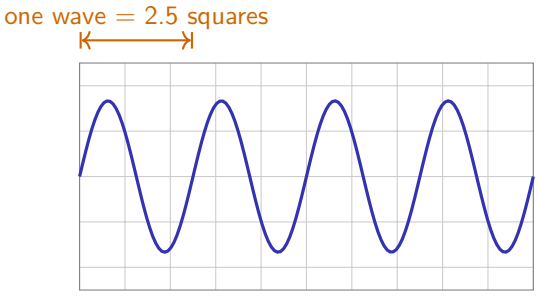
Total internal reflection and the critical angle

1. **Known** Glass, $n = 1.5$; a ray inside meets the surface at 45°.
2. **Equation** $\sin c = 1/n = 1/1.5 = 0.667$.
3. **Angle** $c = \sin^{-1} 0.667 \approx 41.8°$.
4. **Decide** 45° is bigger than 41.8°, so the ray is totally internally reflected.

Decision

Uses: optical fibres for communications and endoscopes, prisms in periscopes.

(P) Reading an oscilloscope trace



time-base: 1 ms per square

2.5 squares $\times$ 1 ms $=$ 2.5 ms, so $f = 1/0.0025\ \mathrm{s} = 400$ Hz. Louder: taller waves, same width.

- Count squares for one complete wave.
- Multiply by the time-base.

(P) Sound, pitch and echoes

1. **Known** Clap 165 m from a wall; echo heard 1.0 s later.
2. **Distance** There and back: $2 \times 165 = 330$ m.
3. **Equation** speed $=$ distance $\div$ time.
4. **Substitute** $v = 330\ \mathrm{m}/1.0\ \mathrm{s} = 330\ \mathrm{m/s}$.

Six mistakes that cost marks

Mistake	**Correct idea**
Angles from the surface	Measure from the normal
TIR as light enters glass	Only inside the denser material, beyond c
Sound is transverse	Sound is longitudinal; all EM waves are transverse
Whole screen as one period	Squares for one wave $\times$ time-base
Echo distance not doubled	Sound goes there and back
Higher f EM waves are faster	All have the same speed in a vacuum

Check yourself

Your turn

Answer without notes, then check.

A. A 500 Hz wave travels at 340 m/s. Wavelength?

B. Order the electromagnetic spectrum by increasing frequency.

C. Which way does light bend entering glass, and leaving it?

D. Glass has $n = 1.5$. Critical angle?

E. (P) What raises pitch, and what raises loudness?