Topic 2 Waves and the Particle Nature of Light
3A Basic waves

3A.1 Wave basics

1 Graphs from top to bottom: 0.2 m, 80 m, 5.5 m

2 1240 m

3 8.15×10^{14} Hz

4 As frequency is defined as waves per second, multiplying frequency by wavelength is equivalent to dividing a distance by a time.

5 Students' own answers, using $v = f\lambda$:

e.g. estimated wavelength is 5 m; estimated frequency is 1 wave every 3 seconds, so $f = 0.33$ Hz

$v = f\lambda = 0.33 \times 5 = 1.7 \text{ m s}^{-1}$

Accept alternative answers using $\frac{\text{distance}}{\text{time}}$

3A.2 Wave types

1 amplitude = 0.5 cm and wavelength = 4.0 cm

2 (a) The oscillations are perpendicular to the direction of energy travel.

(b) P-waves are longitudinal. Rock particles oscillate back and forth in the same line as the direction of the energy travel, causing regions of higher pressure (compressions) and regions of lower pressure (rarefactions).

3 Greater amplitudes of displacement cause greater pressure variations. These affect the parts of the ear to a greater degree, and the brain interprets this as increased loudness.

3A Exam practice

1 B

2 D

3 A

4 A

5 5(a) The amplitude indicates the energy of the sound waves.

This will decrease as the wave travels, so the echo returns with a lower amplitude than the original pulse.

(b) Time from pulse to echo = 50 ms

Distance sound pulse has travelled = 5900 ′ 50 ′ 10-6 = 0.295 m

Depth of rail = 0.295/2 = 0.15 m

5(a) The amplitude indicates the energy of the sound waves.

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Distance sound pulse has travelled = 5900 × 50 × 10-6 = 0.295 m

Depth of rail = 0.295/2 = 0.15 m

6 (a) Any three from:

Sound waves are longitudinal waves

Air molecules vibrate

parallel to the direction of travel of the wave

in a series of compressions and rarefactions

(b) Frequency is the number of cycles / oscillations / waves per second / per unit time OR number of cycles / oscillations / waves passing a point per second

(c) $v = 1500\ \text{m s}^{-1} \times 2\ \text{Hz}$

$v = 3000\ \text{m s}^{-1}$

(d) Animals detect infrasound / lower frequencies than humans / vibrations through the ground and infrasound travels faster than the tidal wave

7 $\lambda = \frac{3 \times 10^8\ \text{m s}^{-1}}{95.8 \times 10^6\ \text{Hz}}$

$\lambda = 3.13$ m

8 (a) (i) They are above the audible range / frequency

(ii) Distance = speed × time

$= 1500\ \text{m s}^{-1} \times 0.8 \times 10^{-4}\ \text{s}$

= 0.12 m

(iii) The idea that one pulse must return before the next is sent

(b) (i) X-rays cause ionisation OR can damage DNA / cells / tissue OR can cause mutation

(ii) Any two from:

X-rays transverse, ultrasound longitudinal OR X-rays can be polarised, ultrasound cannot

X-rays travel in vacuum, ultrasound does not

X-rays electromagnetic, ultrasound mechanical

X-rays have (much) higher f / shorter λ / greater speed

9 (a) After reflection, amplitude is reduced

Because the sound has travelled further OR because the sound has lost some energy/become more spread out

(b) (i) There is only one microphone

(ii) Add a second microphone (attached to the oscilloscope)

(iii) Maximum 6 from:

Set the signal generator to a known frequency, f

Place both microphones the same distance from the loudspeaker

Move one microphone further from the loudspeaker until the two traces have gone (out of phase and then) back again to being in phase

Measure the distance between the two microphones.

This distance equals the wavelength, λ

Calculate speed from $v = f\lambda$

The metal plate will introduce reflections/echoes which will confuse the trace comparisons

(c) 3700 × 0.09

= 333 (m/s)