

Sound, echoes, ultrasound and hearing

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer gives the equation, the substitution and the final value with its unit. Remember to halve the total distance for echoes, and convert prefixes such as kHz, MHz and ms before substituting. Rounding differences in the final digit are acceptable.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** IGCSE 3.4

Problem 1 Sound needs a medium

Sound is a wave that needs particles to pass the vibrations along. In space there is a vacuum with almost no particles, so the vibrations cannot travel and **no sound is transmitted**.

Problem 2 Types of frequency

(a) infrasound (below 20 Hz). (b) audible. (c) audible (18 000 Hz is below 20 000 Hz). (d) **ultrasound** (above 20 kHz).

Problem 3 Simple travel time

$$t = d / v = 660 / 330 = \mathbf{2.0 \text{ s}}$$

Problem 4 Unit conversions

(a) 15 kHz = **15 000 Hz**. (b) 2500 Hz = **2.5 kHz**. (c) 3 ms = $3 \times 10^{-3} \text{ s}$ = **0.003 s**.

Problem 5 Pitch and loudness

B has the higher pitch because it has more waves in the same time (higher frequency). **B** is also louder because its waves are taller (larger amplitude).

Problem 6 Thunderstorm

$$d = v t = 330 \times 4.5 = 1485 \text{ m} = \mathbf{1.5 \text{ km}} \text{ (2 s.f.)}$$

Problem 7 Clap at a cliff

Total distance = $330 \times 1.2 = 396 \text{ m}$. The cliff is half of this: $d = \mathbf{198 \text{ m}}$.

Problem 8 Depth of a lake

$$d = v t / 2 = 1500 \times 0.12 / 2 = \mathbf{90 \text{ m}}$$

Problem 9 Wavelength of notes

(a) $\lambda = v / f = 330 / 440 = \mathbf{0.75 \text{ m}}$

(b) $\lambda = 330 / 20\,000 = 0.0165 \text{ m} = \mathbf{1.65 \text{ cm}}$

Problem 10 Reading an oscilloscope

1. One wave takes 4 divisions, so $T = 4 \times 2.0 = \mathbf{8.0 \text{ ms}} = 0.0080 \text{ s}$.

2. $f = 1 / T = 1 / 0.0080 = \mathbf{125 \text{ Hz}}$

3. The peak is **1.5 divisions** above the middle line.

Problem 11 Rail versus air

Rail: $t = 1500 / 5000 = 0.30 \text{ s}$. Air: $t = 1500 / 330 = 4.5 \text{ s}$. Gap = $4.5 - 0.30 = \mathbf{4.2 \text{ s}}$.

Problem 12 Solid or gas?

Ravi confuses particle motion with wave speed. A sound wave is a vibration passed from particle to particle. In steel the particles are packed tightly and strongly bonded, so each passes the vibration on almost at once. In air the particles are far apart and must travel across gaps first. **Sound is faster in steel (5000 m/s) than in air (330 m/s).**

Problem 13 Spot the error

The student forgot that the sound went to the wall and back. 264 m is the total distance. The wall is at half of this: **132 m**.

Problem 14 Ultrasound wavelength

$f = 2.0 \times 10^6 \text{ Hz}$. $\lambda = 1500 / 2.0 \times 10^6 = 7.5 \times 10^{-4} \text{ m} = \mathbf{0.75 \text{ mm}}$

Problem 15 Depth in a scan

Total distance = $2 \times 0.12 = 0.24 \text{ m}$. $t = 0.24 / 1500 = 1.6 \times 10^{-4} \text{ s} = \mathbf{160 \text{ }\mu\text{s}}$

Problem 16 Two cliffs

1. Near cliff: $330 \times 1.0 / 2 = \mathbf{165 \text{ m}}$. Far cliff: $330 \times 2.5 / 2 = \mathbf{412.5 \text{ m}}$.

2. He stands between them, so the cliffs are $165 + 412.5 = \mathbf{577.5 \text{ m}}$ apart (about 580 m).

Problem 17 A hunting bat

1. $d = 330 \times 0.020 / 2 = \mathbf{3.3 \text{ m}}$

2. $\lambda = 330 / 50\,000 = 0.0066 \text{ m} = \mathbf{6.6 \text{ mm}}$

3. Waves are reflected strongly only by objects larger than about their wavelength. The short

wavelength of ultrasound lets it reflect from small insects.

Problem 18 Speed from a graph

1. $v = 400 / 1.21 = \mathbf{330.6 \text{ m/s}}$ (331 m/s)
2. Gradient = $(400 - 100) / (1.21 - 0.30) = 300 / 0.91 = \mathbf{329.7 \text{ m/s}}$ (330 m/s)
3. $(340 - 329.7) / 340 \times 100 = \mathbf{3.0 \%}$ lower

Problem 19 Cracks in steel

1. $d = 5000 \times 2.0 \times 10^{-4} / 2 = \mathbf{0.50 \text{ m}}$
2. $L = 5000 \times 3.2 \times 10^{-4} / 2 = \mathbf{0.80 \text{ m}}$
3. $0.80 - 0.50 = \mathbf{0.30 \text{ m}}$

Problem 20 Clapping with the echo

Interval = $10.3 / 20 = 0.515 \text{ s}$. This is the round-trip time, so $v = 2 d / t = 2 \times 85.0 / 0.515 = 170 / 0.515 = \mathbf{330 \text{ m/s}}$ (330.1).