

Sound, echoes, ultrasound and hearing

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

Name: _____ Date: _____ Class: _____

These twenty problems practise the speed of sound, echo and sonar calculations, wavelength, hearing ranges and the link between waves and pitch or loudness. You will meet graphs, an oscilloscope screen and ultrasound applications.

They suit GCSE, IGCSE, O Level and Class 9-10 students. Use $v = 330$ m/s in air and 1500 m/s in water unless the problem gives another value.

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

Problem 1 Sound needs a medium (easy)

Explain why an astronaut cannot hear a hammer hitting a satellite when working in space outside the spacecraft.

Problem 2 Types of frequency (easy)

Classify each sound as infrasound, audible or ultrasound for a healthy young person: (a) 15 Hz, (b) 440 Hz, (c) 18 kHz, (d) 45 kHz.

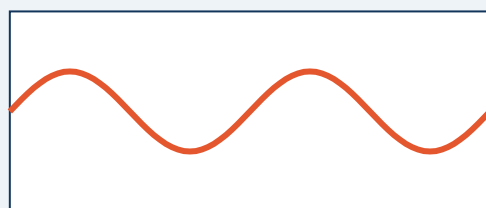
Problem 3 Simple travel time (easy)

Sound travels at 330 m/s in air. Calculate the time it takes to cover 660 m.

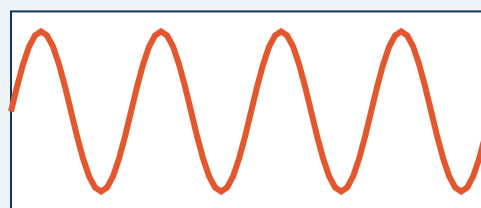
Problem 4 Unit conversions (easy)

Convert (a) 15 kHz to Hz, (b) 2500 Hz to kHz, (c) 3 ms to seconds.

Problem 5 Pitch and loudness (easy)



Sound A



Sound B

Traces of two sounds on the same scales.

Both traces use the same scales. State which sound has the higher pitch and which is louder,

giving a reason for each.

Problem 6 Thunderstorm (medium)

Chiamaka sees lightning over Lagos and hears thunder 4.5 s later. Calculate how far away the strike was. Use 330 m/s.

Problem 7 Clap at a cliff (medium)

A hiker claps and hears an echo 1.2 s later from a cliff. Calculate the distance to the cliff.

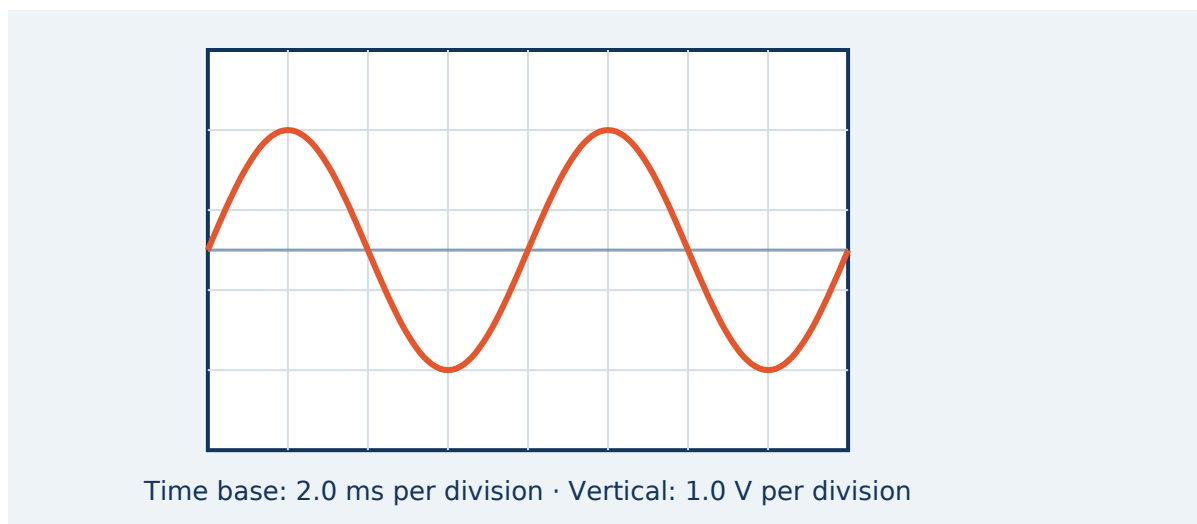
Problem 8 Depth of a lake (medium)

A sonar pulse returns from the bottom of a lake after 0.12 s. The speed of sound in water is 1500 m/s. Calculate the depth.

Problem 9 Wavelength of notes (medium)

Calculate the wavelength in air of (a) a note of 440 Hz and (b) a sound of 20 000 Hz. Use $v = 330$ m/s.

Problem 10 Reading an oscilloscope (medium)



Oscilloscope trace of a sound picked up by a microphone.

Use the time base 2.0 ms per division.

1. Find the period of the sound.
2. Calculate the frequency.
3. State the number of vertical divisions from the middle line to a peak.

Problem 11 Rail versus air (medium)

Aarav hits a steel rail with a hammer. His friend, 1500 m away, puts an ear to the rail (sound speed 5000 m/s) and also hears the sound through the air (330 m/s). Calculate the time gap

between the two sounds.

Problem 12 Solid or gas? (medium)

Ravi says: the particles of air zoom about at hundreds of metres per second, so sound must travel fastest in air. Evaluate his idea using what you know about sound in steel.

Problem 13 Spot the error (medium)

A student hears an echo 0.80 s after shouting at a wall and writes: $d = 330 \times 0.80 = 264$ m. Explain the mistake and correct it.

Problem 14 Ultrasound wavelength (medium)

An ultrasound probe uses a frequency of 2.0 MHz in body tissue, where the speed is 1500 m/s. Calculate the wavelength in millimetres.

Problem 15 Depth in a scan (medium)

In a scan, a pulse reflects from a boundary 12 cm below the skin. The speed in tissue is 1500 m/s. Calculate the time for the pulse to go and return, in microseconds.

Problem 16 Two cliffs (hard)

Diego in Texas stands between two parallel cliffs and shouts. He hears the first echo after 1.0 s and the second after 2.5 s. Use 330 m/s.

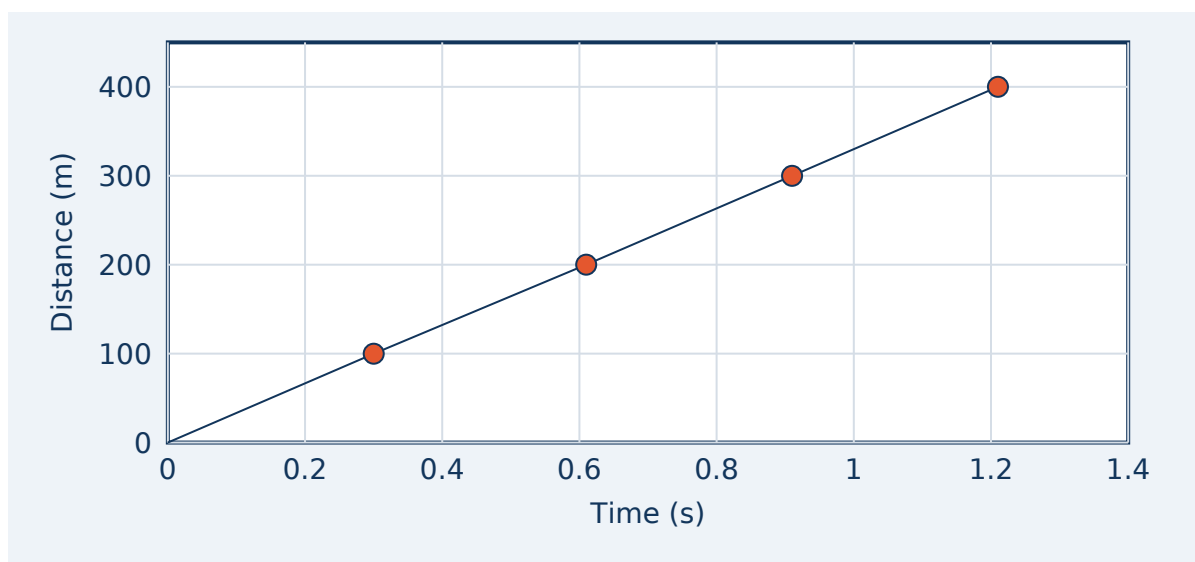
1. Calculate his distance from each cliff.
2. Calculate the distance between the cliffs.

Problem 17 A hunting bat (hard)

A bat emits ultrasound at 50 kHz and hears the echo from a moth after 0.020 s. Use 330 m/s.

1. Calculate the distance to the moth.
2. Calculate the wavelength of the ultrasound.
3. Suggest why bats use high-frequency sound to find small insects.

Problem 18 Speed from a graph (hard)

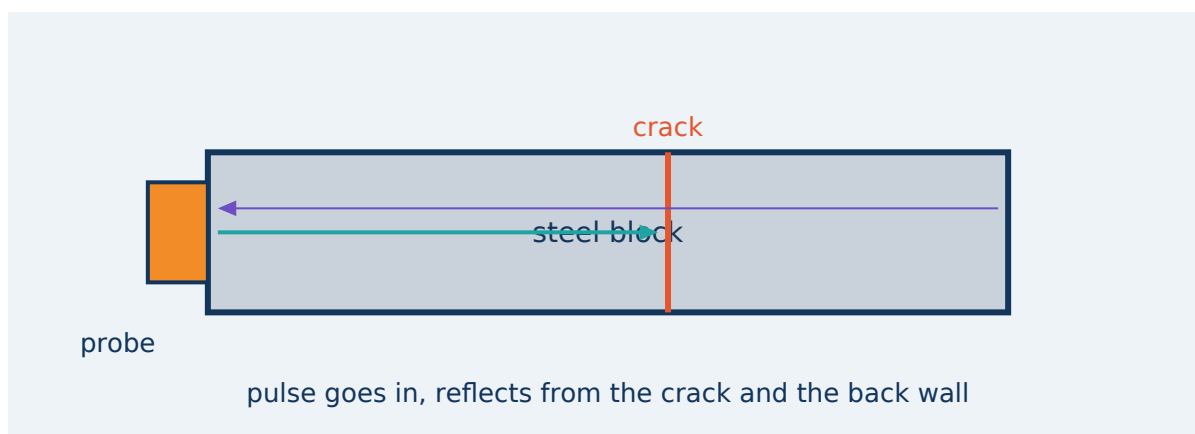


Time for the sound of a starter pistol to reach microphones at different distances.

Microphones at different distances record a starter pistol.

1. Calculate the speed for the 400 m point.
2. Find the gradient using the points at 100 m and 400 m.
3. A data book says 340 m/s. Calculate the percentage difference between your gradient and 340.

Problem 19 Cracks in steel (hard)



Ultrasonic testing of a steel block 0.80 m long.

An ultrasonic pulse goes into a steel block (5000 m/s) and two echoes return: after 2.0×10^{-4} s from the crack and after 3.2×10^{-4} s from the back wall.

1. Calculate the depth of the crack.
2. Calculate the length of the block.
3. Calculate the distance from the crack to the back wall.

Problem 20 Clapping with the echo (hard)

Wanjiru stands 85.0 m from a large wall and claps so that each clap coincides with the echo of the previous clap. Twenty intervals between claps take 10.3 s. Calculate the speed of sound.