EXERCISE 2.3

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Gr 10 Physical Sciences 3-in-1

QUESTION 1

1.1 What type of waves are sound waves?

1.2 What is needed for sound waves to be propagated from one place to another?

1.3 Draw a simple diagram and write short notes to explain how sound waves are propagated from a speaker's mouth to a listener's ear.

1.4 Arrange the different media: water, oil, iron, air at 15ºC and air at 40ºC in the order of increasing propagation speed of sound through these media. Give an explanation for your answer.

1.5 Take the speed of sound as 335 $m \cdot s^{-1}$. How long will a sound wave take to travel 2 km?

1.6 If the timekeeper stands on the finishing line of an athletics track, and the person that fires the gun to start the race stands a 100 m away from him:

1.6.1 What influence will it have on the time reading taken for an athlete to complete the race? Will it be slightly more or less than the actual time? Give a reason for your answer.

1.6.2 Calculate the speed of sound in air, if the time deviation is 0,3 s.

QUESTION 2

2.1 Jane is standing 85 m from a high cliff. She hits a drum with a stick and hears the echo of the sound an instant later. Take the speed of sound in air on that specific day as 340 $m \cdot s^{-1}$ and calculate the time lapse from the moment she hits the drum until she hears the echo.

2.2 A man stands on an open square between two high buildings. He blows on a vuvuzela. He hears the echo from the one building after 1,5 s and from the other building after 2,5 s. Calculate the distance between the two buildings. Take the speed of sound in air as 330 $m \cdot s^{-1}$.

QUESTION 3

3.1 Calculate the wavelength of a sound wave produced by a guitar string if the speed of sound in air is 340 $m \cdot s^{-1}$ and the frequency of the wave is 450 Hz.

3.2 Calculate the period of a sound wave that has a wavelength of 0,03 m and a speed of 330 $m \cdot s^{-1}$.

3.3 Calculate the speed of sound in seawater if a dolphin makes a whistling sound with a frequency of 30 kHz and a wavelength of 5 m.

QUESTION 4

4.1 Ships and boats can determine the depth of water beneath them using an 'echo-sounding' method known as ultrasound.

4.1.1 Define the term *ultrasound*.

4.1.2 A ship transmits a sound wave which is reflected off the seabed. Explain why the reflected sound is **softer** than the original sound.

4.1.3 A ship transmits a sound wave and the echo is heard 3 seconds later. Calculate the depth of the seabed (**in kilometres**) if the speed of the sound in water is 1 510 $m \cdot s^{-1}$.

4.1.4 If the wavelength of the sound waves is 0,05 m, determine the frequency of the waves in kHz.

4.2 Name ONE animal that uses ultrasound when navigating through its natural habitat.

4.3 Give TWO medical applications and TWO everyday applications of ultrasound.

EXERCISE ANSWERS

QUESTION 1

1.1 Longitudinal waves

1.2 A medium (energy must be transferred to the particles of the medium).

1.3 Sound waves are generated by vibrations in a medium. These vibrations are propagated through the surrounding medium, e.g. air to a listener's ear by a series of compressions and rarefactions of the particles in the medium.

1.4 Air at 15°C, air at 40°C, water, oil, iron.

- The more closely the particles in the medium are packed (the higher the density of the medium), the faster a sound wave is propagated.
- The speed of sound increases with an increase in the temperature of the medium, because the particles vibrate more vigorously and transfer the energy better between them.

1.5 $\Delta t = \dfrac{\Delta x}{v}$

$= \dfrac{2\ 000}{335}$

$= 5{,}97$ s

$\Delta x = 2$ km $= 2\ 000$ m
$v = 335$ m·s^{-1}

1.6.1 It will be slightly less. He will start the watch slightly after the gun was fired, because the sound will take a short while to travel the 100 m to reach him.

1.6.2 $v = \dfrac{\Delta x}{\Delta t}$

$= \dfrac{100}{0{,}3}$

$= 333{,}33$ m·s^{-1}

$\Delta x = 100$ m
$\Delta t = 0{,}3$ s

QUESTION 2

2.1 $\Delta t = \dfrac{\Delta x}{v}$

$= \dfrac{85 \times 2}{340}$

$= 0{,}5$ s

$\Delta x = 85 \times 2 = 170$ m
$v = 340$ m·s^{-1}

2.2 $\Delta x_{tot} = \Delta x_1 + \Delta x_2$

$= v\Delta t_1 + v\Delta t_2$

$= (340 \times 1{,}5) + (340 \times 2{,}5)$

$= 510 + 850$

$= 1\ 360$ m

$\therefore \Delta x$ between buildings $= \dfrac{1\ 360}{2}$

$= 680$ m

$t_1 = 1{,}5$ s
$t_2 = 2{,}5$ s
$v = 340$ m·s^{-1}

OR

Divide by t_1 and t_2 by 2:

$\dfrac{1{,}5 + 2{,}5}{2} = 2$ s

$\therefore \Delta x = v\Delta t$

$= 340 \times 2$

NOTE

The sound travels from him to the buildings and is reflected back, therefore in only half the time, the sound travelled to the buildings.

$= 680$ s

QUESTION 3

3.1
$$v = f\lambda$$
$$\therefore 340 = 450\,\lambda$$
$$\therefore \lambda = \frac{340}{450}$$
$$= 0{,}76 \text{ m}$$

$v = 340$ m·s^{-1}
$f = 450$ Hz

3.2
$$v = f\lambda$$
$$\therefore v = \frac{\lambda}{T}$$
$$\therefore 330 = \frac{0{,}03}{T}$$
$$\therefore T = \frac{0{,}03}{330}$$
$$= 9 \times 10^{-5} \text{ s}$$

$\lambda = 0{,}03$ m
$v = 330$ m·s^{-1}

3.3
$$v = f\lambda$$
$$= 30\,000 \times 0{,}05$$
$$= 1\,500 \text{ m·s}^{-1}$$

$f = 30$ kHz
$= 30\,000$ Hz
$\lambda = 0{,}03$ m

QUESTION 4

4.1.1 Ultrasound refers to sound with very high frequencies, i.e. of frequencies between 20 kHz to 150 kHz.

4.1.2 The sound is partially absorbed and partially reflected by the seabed.

4.1.3
$$\Delta x = v\Delta t$$
$$= 1\,510 \times 1{,}5$$
$$= 2\,265 \text{ m}$$
$$= 2{,}265 \text{ km}$$

$\Delta t = 3 \div 2$
$= 1{,}5$ s
$v = 1\,510$ m·s^{-1}

4.1.4
$$v = f\lambda$$
$$\therefore 1\,510 = f(0{,}05)$$
$$\therefore f = 30\,200 \text{ Hz}$$
$$= 30{,}2 \text{ kHz}$$

4.2 dolphins or bats

4.3 Medical solutions: take a sonar image of an unborn baby;
determine blood flow rate when there are blockages in veins;
to break kidney stones or gallstones; to clean teeth by a dentist *(any 2)*

Other solutions: detect small cracks in the wings of an aircraft; determine thickness of metals or plastics; clean delicate mechanism of old-fashioned clocks and watches.