3.4 Waves: Light and Sound: 1-hour Pack

Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student times the delay between seeing lightning and hearing thunder. The delay is 6.0 s. Use speed of sound in air = 340 m/s. Calculate the distance to the lightning in metres. Give your answer to three significant figures.

(a) Distance = speed x time. Calculate the distance to the lightning. **(3)**

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2 A ripple tank produces waves. A student measures the distance covering 6 wavelengths as 1.44 m. Calculate the wavelength of the waves in metres. Show your working.

(a) Wavelength = total distance / number of wavelengths. Calculate the wavelength. **(4)**

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3 A tuning fork produces a sound at frequency 440 Hz. A student hears a sound from a second tuning fork and measures its frequency as 452 Hz. Calculate the percentage difference in frequency between the two forks. Give your answer to two significant figures.

(a) Percentage difference = (change / original) x 100. Calculate the percentage difference using 440 Hz as the original. **(4)**

4 An ultrasound pulse takes 36 microseconds (3.6×10^{-5} s) to travel through soft tissue and return from a structure 18 mm deep. Assuming the pulse travels to the structure and back in the given time, calculate the speed of sound in the tissue. Show working. (Distance given is one way.)

(3)

5 State which of the following can be reflected: radio waves, sound waves, water waves. Give yes or no for each.

(2)

6 A red laser and a green laser are pointed at a white screen. Explain why the white screen shows different coloured spots for each laser.

(3)

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7 A student notices that when they move away from a siren the pitch seems lower than when they move towards it. Name this effect and give a short explanation.

(2)

8 Complete the sentence and explain your answer: Sound needs a material medium to travel, so it cannot travel through _____.

(2)

9 A student sets up a ripple tank with regular waves approaching a gap in a barrier. Describe what happens to the waves after they pass through the gap and name the process.

(3)

10 Name two parts of the ear involved in detecting sound and give one function for each.

(2)

11 Explain why sound becomes quieter with distance from the source. Give one clear reason.

(2)

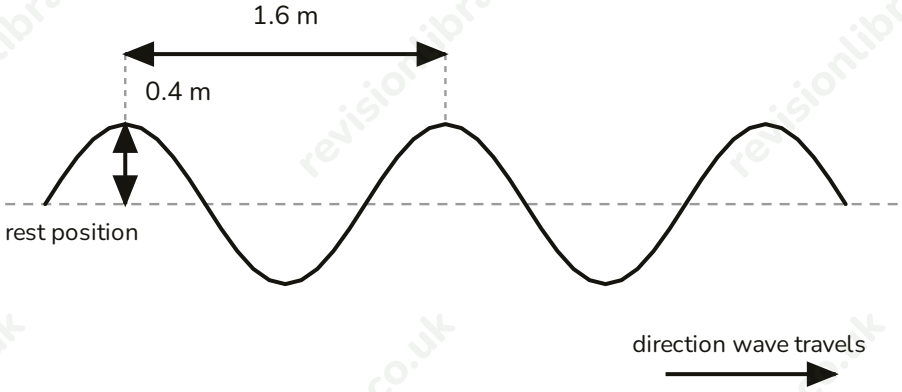
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12 State what is measured by the amplitude of a sound wave and which property of the sound it affects.

(2)

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13 The diagram shows a wave travelling along a rope. The source is moved from side to side, and the rope itself moves up and down as the wave travels along its length. Two distances are marked on the diagram.



(a) State the amplitude of the wave. **(1)**

(b) State the wavelength of the wave. **(1)**

(c) State whether this wave is transverse or longitudinal. Give a reason for your answer, based on the direction of the oscillations compared with the direction the wave travels. **(2)**

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14 For each statement about pitch and loudness, identify the correct option.

(a) Increasing the amplitude of a sound wave makes the sound: **(1)**

- ☐ A) Louder
- ☐ B) Higher pitched

(b) Increasing the frequency of a sound wave makes the sound: **(1)**

- ☐ A) Louder
- ☐ B) Higher pitched

(c) A bass guitar string, compared with a violin string, usually produces a sound with a: **(1)**

- ☐ A) Lower frequency
- ☐ B) Higher frequency

(d) A quieter sound of the same pitch would show, on an oscilloscope trace: **(1)**

- ☐ A) A smaller amplitude trace
- ☐ B) A larger amplitude trace

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15 The normal human hearing range is approximately 20 Hz to 20,000 Hz. A dog whistle emits sound at a frequency of 35,000 Hz.

(a) State whether a human can hear the dog whistle directly. Give a reason for your answer. **(2)**

(b) Sound waves with a frequency above the upper limit of human hearing are given a specific name. State this name. **(1)**

(c) Give one medical use of ultrasound. **(1)**

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16 A sound wave has a frequency of 250 Hz. Use the equation: time period T (s) = 1 / frequency f (Hz).

(a) Calculate the time period of this wave. Give your answer in standard form. **(3)**

17 Compare how light waves and sound waves transfer energy, and explain one key difference in how each type of wave behaves. In your answer, refer to: whether each wave is transverse or longitudinal; what each wave needs in order to travel; and one everyday application of each wave type.

(6)

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Mark scheme · 3.4 Waves: Light and Sound: 1-hour Pack

Question 1

(a) substitute distance = 340 x 6.0	M1
(a) perform multiplication 340 x 6.0 = 2040	M1
(a) 2040 m cao	A1

(a) Answer: **2040 m**

Question 2

(a) identify wavelength = 1.44 / 6	M1
(a) perform division 1.44 / 6 = 0.24	M1
(a) 0.24 m cao	A1
(a) answer given with unit m	B1

(a) Answer: **0.24 m**

Question 3

(a) calculate change = 452 - 440 = 12 Hz	M1
(a) substitute percentage = (12 / 440) x 100	M1
(a) perform calculation (12 / 440) x 100 = 2.727... percent	M1
(a) 2.7% to two significant figures cao	A1

(a) Answer: **2.7%**

Question 4

use total distance = 2 x 18 mm = 36 mm = 0.036 m and speed = distance / time	M1
1000 m/s cao	A1
show unit m/s	B1

Answer: **1000 m/s**

Question 5

radio waves: yes (electromagnetic waves reflect from metal surfaces)	B1
sound waves: yes (echoes show reflection)	B1

Answer: **Radio waves: yes. Sound waves: yes. Water waves: yes.**

Question 6

state that lasers emit light of a single colour (single wavelength) each	M1
explain that white screen reflects the light so the spot appears the colour of the laser	A1
mention that human eyes detect different wavelengths as different colours (red vs green) or that mixing would be needed for white, oe	B1

Answer: **Each laser emits light of a single wavelength; the white screen reflects that light so the spot appears the colour of the laser, and our eyes detect different wavelengths as different colours.**

Question 7

Doppler effect or Doppler shift named	B1
explain that relative motion changes frequency heard: moving away reduces frequency so pitch lower, moving towards increases frequency so pitch higher	B1

Answer: **Doppler effect: because relative motion between source and observer changes the frequency reaching the ear; moving away reduces the frequency heard so the pitch is lower.**

Question 8

vacuum cao	B1
explain that a vacuum has no particles to carry vibrations	B1

Answer: **vacuum (a vacuum has no particles to carry the vibrations)**

Question 9

state that waves spread out after passing through the gap	M1
use the word diffraction cao	A1
mention that spreading is greater when gap is similar in size to wavelength or when gap is narrow, oe	B1

Answer: **The waves spread out after passing through the gap; this is called diffraction. The spreading is larger when the gap size is similar to the wavelength or when the gap is narrow.**

Question 10

a first valid part of the ear with a correct function, e.g. outer ear/pinna collects and directs sound into the ear canal, or the ear canal carries vibrations to the eardrum	B1
a second, different valid part with a correct function, e.g. eardrum vibrates in response to sound / ossicles (small bones) amplify vibrations / cochlea converts vibrations to electrical signals / auditory nerve carries signals to the brain	B1

Answer: **Pinna (outer ear) collects and directs sound into the ear canal; eardrum vibrates when sound waves hit it (ossicles then amplify vibrations).**

Question 11

sound energy spreads out over a larger area as distance increases (intensity decreases)	M1
so the energy reaching your ear per second is less and the sound is quieter cao	A1

Answer: **Sound energy spreads out over a larger area as distance increases, so less energy reaches the ear per second and the sound is quieter.**

Question 12

loudness or volume is related to amplitude	B1
amplitude measures maximum displacement of particles from rest / size of pressure variation, oe	B1

Answer: **Amplitude measures the maximum displacement of particles (size of pressure variation) and is related to the loudness of the sound.**

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Question 13

(a) 0.4 m, cao **B1**

(a) Answer: **0.4 m**

(b) 1.6 m, cao **B1**

(b) Answer: **1.6 m**

(c) transverse **B1**

(c) reason: the rope oscillates up and down at right angles (perpendicular) to the direction the wave travels along the rope, oe **B1**

(c) Answer: **Transverse; the rope's oscillations are perpendicular to the direction of energy transfer.**

Question 14

(a) A **B1**

(a) Answer: **A) Louder**

(b) B **B1**

(b) Answer: **B) Higher pitched**

(c) A **B1**

(c) Answer: **A) Lower frequency**

(d) A **B1**

(d) Answer: **A) A smaller amplitude trace**

Question 15

(a) no **B1**

(a) 35,000 Hz is above the upper limit of human hearing (20,000 Hz), oe **B1**

(a) Answer: **No, because 35,000 Hz is above the upper limit of human hearing (20,000 Hz).**

(b) ultrasound **B1**

(b) Answer: **Ultrasound**

(c) e.g. prenatal (pregnancy) scanning to image a foetus, or breaking up kidney stones, oe (accept any valid medical use) **B1**

(c) Answer: **Prenatal scanning to produce images of a foetus (or breaking up kidney stones).**

Question 16

(a) correct substitution: T = 1 / 250 **M1**

(a) 0.004 s **A1**

(a) 4 x 10^{-3} s, cao (standard form) **A1**

(a) Answer: **4 x 10^{-3} s (0.004 s)**

Question 17

Level 1 Basic, largely isolated statements are made about light and/or sound, with limited or no accurate comparison. Little or no reference to wave type, medium, or applications. **1-2**

Level 2 Some accurate comparison points are made, with partial explanation linking wave type (transverse/longitudinal) and/or medium requirements to light and sound. At least one relevant application is given. The answer has some structure. **3-4**

Level 3 A detailed, logically structured comparison is given, correctly covering wave type, medium requirements, and applications for both light and sound, with clear and accurate scientific reasoning linking the ideas throughout. **5-6**

Indicative content:

- Light is a transverse wave; sound is a longitudinal wave.
- In a transverse wave the oscillations are perpendicular (at right angles) to the direction of energy transfer; in a longitudinal wave the oscillations are parallel to (along) the direction of energy transfer.
- Light is an electromagnetic wave and does not need a medium/particles to travel, so it can travel through a vacuum.
- Sound needs a medium containing particles (solid, liquid or gas) because it travels as compressions and rarefactions of particles.
- Both light and sound waves transfer energy without an overall (net) transfer of matter.
- Light travels much faster than sound (about 3 x 10^8 m/s compared with about 340 m/s for sound in air), which is why thunder is heard after lightning is seen.
- Both light and sound can be reflected (e.g. echoes for sound, mirrors for light) and can be refracted.
- Example use of light: e.g. optical fibres for communication, mirrors/periscopes, or photography.
- Example use of sound: e.g. ultrasound for medical scanning, sonar for detecting underwater objects, or musical instruments.

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