3.7 Sound Waves and Ultrasound: 30-minute Pack

Total Marks

EDEXCEL 4PH1 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A technician uses ultrasound at 25 kHz for an industrial cleaning bath. State whether this frequency is ultrasound and give its value in hertz.

(Total for Question 1 is 1 mark)

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2 State the typical audible frequency range for a healthy human ear, naming both the low and high frequency limits.

(Total for Question 2 is 1 mark)

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3 A sound source emits a steady tone at frequency 1000 Hz. State whether this frequency is within the typical human hearing range and explain your answer briefly.

(Total for Question 3 is 2 marks)

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4 State one safety advantage of ultrasound imaging compared with X-ray imaging when scanning a pregnant woman, and give a short reason.

(Total for Question 4 is 1 mark)

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5 State the equation relating wave speed, frequency and wavelength and name each symbol, in the context of sound waves in air.

(Total for Question 5 is 2 marks)

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6 State the definition of ultrasound in terms of frequency, naming the threshold above which waves are classed as ultrasound.

(Total for Question 6 is 1 mark)

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7 Describe briefly how an ultrasonic flaw detector locates a crack inside a metal block, naming the role of partial reflection at a boundary between media.

(Total for Question 7 is 3 marks)

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8 A student uses an apparatus to measure the speed of sound in air. She emits a short sharp sound near a flat wall and records echo times at different known distances. She records an echo time of 0.30 s when standing 51 m from the wall. Using this data point, calculate the measured speed of sound implied by these values.

(Total for Question 8 is 3 marks)

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9 An echo is used to measure the distance to a cliff face. A student stands at a lake shore and emits a loud sound. The echo is heard 2.4 s later. Using speed of sound in air as 340 m/s, calculate the distance from the student to the cliff face.

(Total for Question 9 is 3 marks)

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10 A bat emits ultrasonic pulses and measures echoes to locate prey. If the bat emits pulses at 50 kHz and the speed of sound in air is 340 m/s, calculate the wavelength of these ultrasonic pulses.

(Total for Question 10 is 3 marks)

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11 A medical ultrasound scan sends pulses into the body and detects echoes from tissue boundaries. A pulse reflects from a boundary 4.0 cm below the probe and the echo returns to the probe in 5.9×10^{-5} s. Calculate the speed of ultrasound in the tissue. Use the fact the pulse travelled to the boundary and back.

(Total for Question 11 is 3 marks)

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12 Explain how ultrasound is used to produce an image of a fetus during prenatal scanning, including how echoes are used to build the image and why ultrasound is suitable for soft tissues.

(Total for Question 12 is 4 marks)

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Mark scheme · 3.7 Sound Waves and Ultrasound: 30-minute Pack

Question 1

yes, it is ultrasound and 25 kHz = 25000 Hz **B1**

Answer: Yes, it is ultrasound; 25 kHz = 25000 Hz

Question 2

20 Hz to 20000 Hz (20 kHz) **B1**

Answer: About 20 Hz to 20000 Hz

Question 3

states it is within the human hearing range **B1**

gives correct brief reason, e.g. 1000 Hz is between 20 Hz and 20000 Hz **B1**

Answer: Yes, 1000 Hz is within the human hearing range, because it lies between 20 Hz and 20000 Hz

Question 4

states that ultrasound is non-ionising so it does not damage DNA like X-rays might **B1**

Answer: Ultrasound is non-ionising, so it does not carry the same risk of DNA damage as X-rays

Question 5

$v = f \times \lambda$ or $v = f \times \lambda$ written correctly **B1**

identifies symbols: v is wave speed, f is frequency, λ is wavelength **B1**

Answer: $v = f \times \lambda$, where v is wave speed, f is frequency and λ is wavelength

Question 6

ultrasound has frequency above 20000 Hz **B1**

Answer: Ultrasound is sound with frequency above 20000 Hz

Question 7

sends ultrasound pulses into the metal using a transducer **B1**

partial reflection occurs at boundaries where material properties change, e.g. at a crack or void, producing an echo **B1**

time delay of the echo and known speed of ultrasound in the metal gives distance to the flaw **B1**

Answer: Ultrasound pulses are sent into the metal; pulses are partially reflected at a crack or boundary producing echoes; the time delay and known sound speed give the flaw distance

Question 8

recognises total distance = 2 x 51 m = 102 m and sets speed = distance / time **M1**

computes speed = 102 / 0.30 **M1**

speed = 340 m/s cao (equals 340 m/s) **A1**

Answer: 340 m/s

Question 9

knows total travel time corresponds to sound going to cliff and back, so time to cliff = 2.4 / 2 **M1**

uses distance = speed x time with t = 1.2 s, so distance = 340 x 1.2 **M1**

distance = 408 m cao **A1**

Answer: 408 m

Question 10

uses $\lambda = v / f$ and substitutes v = 340 m/s and f = 50000 Hz **M1**

performs division 340 / 50000 **M1**

$\lambda = 0.0068$ m cao (6.8×10^{-3} m, allow 0.0068 m) **A1**

Answer: 0.0068 m (6.8 mm)

Question 11

recognises total distance = 2 x 4.0 cm = 8.0 cm = 0.080 m **M1**

uses speed = distance / time with distance 0.080 m and time 5.9×10^{-5} s **M1**

speed = 1360 m/s cao (allow 1350-1360 m/s or 1.36×10^{3} m/s depending on rounding) **A1**

Answer: About 1360 m/s (1.36×10^{3} m/s)

Question 12

transducer sends short ultrasound pulses into the body and receives returning echoes **B1**

partial reflections occur at boundaries between different tissues, each echo indicates a boundary at a certain depth **B1**

computer measures time and amplitude of many echoes from across a region and converts them into a two dimensional image **B1**

ultrasound is suitable because it is non-ionising and is strongly reflected by tissue boundaries while penetrating soft tissue reasonably well **B1**

Answer: A transducer emits pulses and detects echoes from tissue boundaries; timing and strength of echoes from many directions are processed into an image; ultrasound penetrates soft tissue and is non-ionising so it is suitable for prenatal imaging

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