O Level Pure Physics Structured

Sound Test 2.0

Q1

A man is using an auto-focus camera to take a picture of an object. The camera determines the distance between the camera and the object by bouncing an ultrasonic sound wave off the object.

(a) Explain why the man is unable to hear the sound wave.

_____

_____ [1]

(b) Explain why the auto-focus function of the camera will not work if the man tries to take a picture of the scenery from inside a bus, through a window pane.

_____

_____ [1]

(c) The distance between the camera and the object to be taken is 2.4 m. If the speed of sound in air is 340 m/s, calculate the time taken for the sound wave to return to the camera after leaving the camera.

time taken = _____ [2]

(d) Suggest whether this method of auto-focus can be used for cameras in space and explain your answer.

_____

_____

_____

_____ [2]

Q2

An ultrasonic sensor is a sensor that measures distance using sound. A short pulse of sound waves travelling at 333 m s^{-1} produces an echo from a wall. The echo arrives back at the sensor 0.12 s after the pulse is produced.

(a) Calculate the distance from the sensor to the wall.

distance = ... [2]

The wavelength of the sound wave is 30 mm.

(b) Calculate the frequency of the sound wave.

frequency = ... [1]

The sound wave produces compressions and rarefactions in the air as it passes.

(c) Calculate the distance between a compression and the nearest rarefaction.

distance = ... [1]

(d) State **two** reasons why such sensors must operate at ultrasonic frequencies.

.....

..... [2]

Q3

Explain how sound is transmitted from the loudspeaker to the ears of a person. [2]

.....

.....

.....

Q4

A hammer is used to strike one end of a 900 m long hollow metal pipe. A data logger connected with a sensitive sound detector at the other end registers two sounds at an interval of 2.3 s between them. (Take speed of sound in air = 330 ms^{-1})

a. Explain why there are two sounds registered at an interval of 2.3 s apart.

[1]

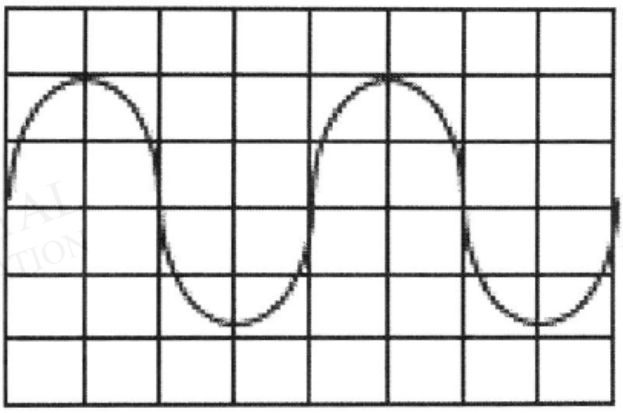
b. Calculate the time taken for sound to travel 900 m in air.

[1]

c. Calculate the speed of sound in the metal pipe.

[2]

d. The hammer is then used to hit the pipe again. The figure below shows the waveform that is registered by the data logger. The waveform represents the sound in the metal pipe.



On the figure above, draw a new waveform to represent the new sound wave that is formed when the hammer is now hitting the pipe with **more** force.

[2]

Q5

Ultrasound is used in quality control to detect cracks in metal. Pulses of ultrasound are sent into the metal from a transmitter placed on the front surface of the metal. A detector placed next to the transmitter picks up the pulses reflected from the back surface of the metal.

Fig. 4.1 shows the oscilloscope trace of the ultrasound pulses produced for a piece of metal that contains no cracks. One division along the x-axis represents 1.0×10^{-6} s.

Pulses labelled **S** are the ones sent out from the transmitter. Each pulse labelled **R** is the reflection of **S** from the back surface of the metal.

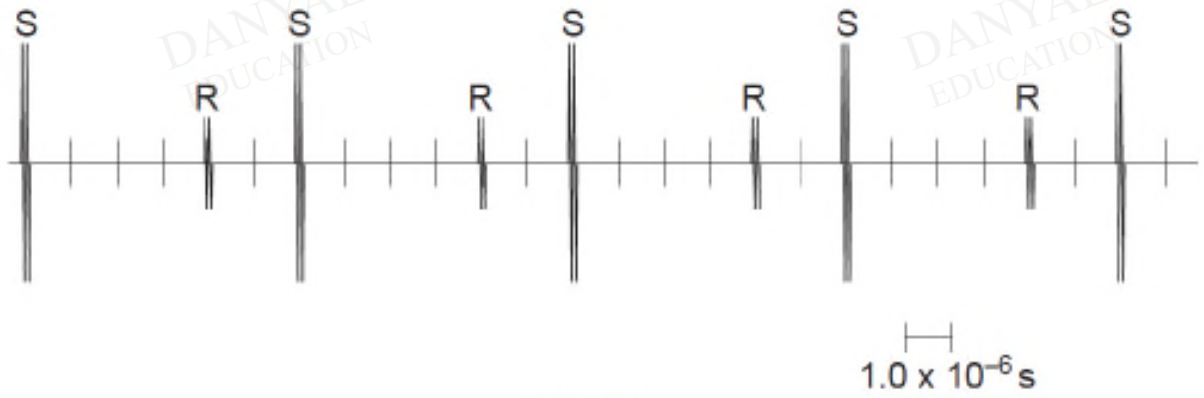


Fig. 4.1

(a) State what is meant by *ultrasound*.

_____

_____ [1]

(b) Suggest one reason why the amplitude of **R** is less than the amplitude of **S**.

_____

_____

_____ [1]

(c) Use Fig. 4.1 to calculate the number of pulses sent out by the source in one second.

number of pulses = _____ [1]

(d) The speed of ultrasound in the piece of metal in Fig. 4.1 is 5000 m/s.
Calculate the thickness of the piece of metal.

thickness = _____ [2]

(e) A while later, the piece of metal is tested again. It now has a small crack half-way between the front surface and the back surface.

On Fig. 4.1, draw the position of the pulses produced by this crack. Label each of these pulses **C**. [1]

Answers

Sound Test 2.0

Q1

(a) The ultrasonic sound wave is beyond the audible range of frequency of the human ear. **[1]**

(b) The sound wave will be reflected from the window of the bus and the distance measured by the camera would be the distance between the camera and the window. **[1]**

(c) time = (2 x 2.4) / 340 **[1]**
= 0.0141 s **[1]**

(d) It cannot be used in space
because sound waves cannot travel in vacuum. **[1]** **[1]**

Q2

a	Dist = spd x time or dist = 333 x 0.06 or dist = 0.5(333 x 0.12) Dist = 20 m	M1 A1
b	v = fλ or 333 = f(0.03) f = 11100 Hz	 B1
c	15 mm	B1
d	Noise pollution / disturb other humans Background noise doesn't affect operation	B1 B1

Q3

The vibration from the loudspeaker vibrates/disturbs the air particles around it. This causes a transfer of energy is in the form of longitudinal waves where the air particles undergo a series of compression and rarefactions until the energy is transferred to the ears.	A2

Q4

a. Explain why there are two sounds registered at an interval of 2.3 s apart?

[1]

One sound is from travelling through the air. A1/2

The second sound is from travelling through the metal pipe. A1/2

b. Calculate the time taken for sound to travel 900 m in air.

[1]

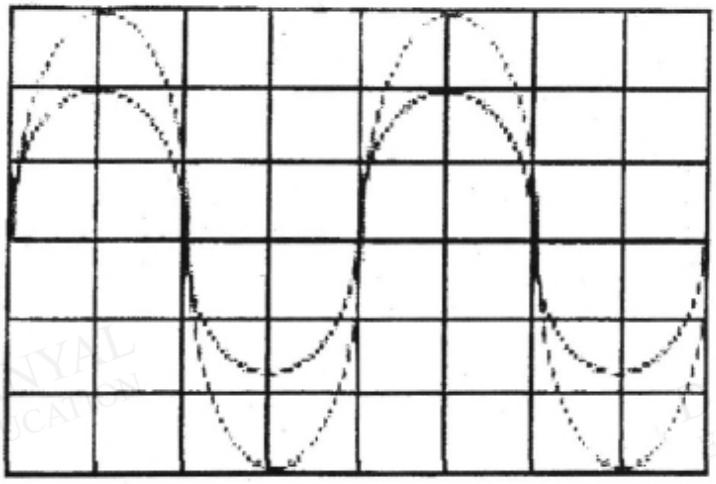
t = Distance ÷ Speed = 900 / 330
t = 900 / 330
t = 2.73 s. A1

c. Calculate the speed of sound in the metal pipe.

[2]

Time taken = 2.73 – 2.3
Time taken = 0.43 s A1
Speed = 900 / 0.43
Speed = 2093 m/s A1

d. The hammer is then used to hit the pipe again. Figure 6.1 shows the waveform that is registered by the data logger. The waveform represents the sound in the metal pipe.

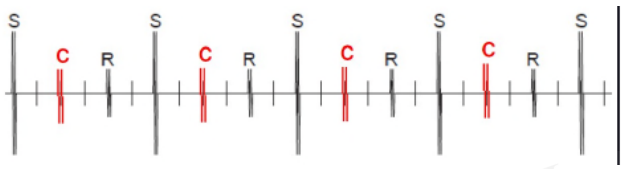


On the figure above, draw a new waveform to represent the new sound wave that is formed when the hammer is now hitting the pipe with ***more*** force.

[2]

Larger amplitude A1
Same frequency A1

Q5

(a)	Ultrasound is sound that has a frequency of above 20 kHz / above human audible frequency range.	[1]	
(b)	Not all sound is reflected from back surface as some passes through the back surface. / Some energy/sound is absorbed by the metal. / Sound/energy spreads out/scattered/reflected in other directions. (any one)	[1]	Do not accept 'sound energy is lost' without any elaboration.
(c)	No of pulses = $1/ (6.0 \times 10^{-6})$ $= 1.7 \times 10^{5}$	 [1]	
(d)	Thickness = ½ x v x t = ½ x 5000 x (4.0×10^{-6}) = 0.010 m	[1] [1]	Max [1] awarded if factor of '1/2' is missing.
(e)		[1]	All four 'C' must be drawn and labelled.