O Level Pure Physics Structured

Sound Test 1.0

Q1

Ultrasound may be used to measure distances. Fig. 7.1 shows a setup consisting of a cathode-ray oscilloscope (CRO) connected to a microphone, a pulse generator and a reflecting wall.

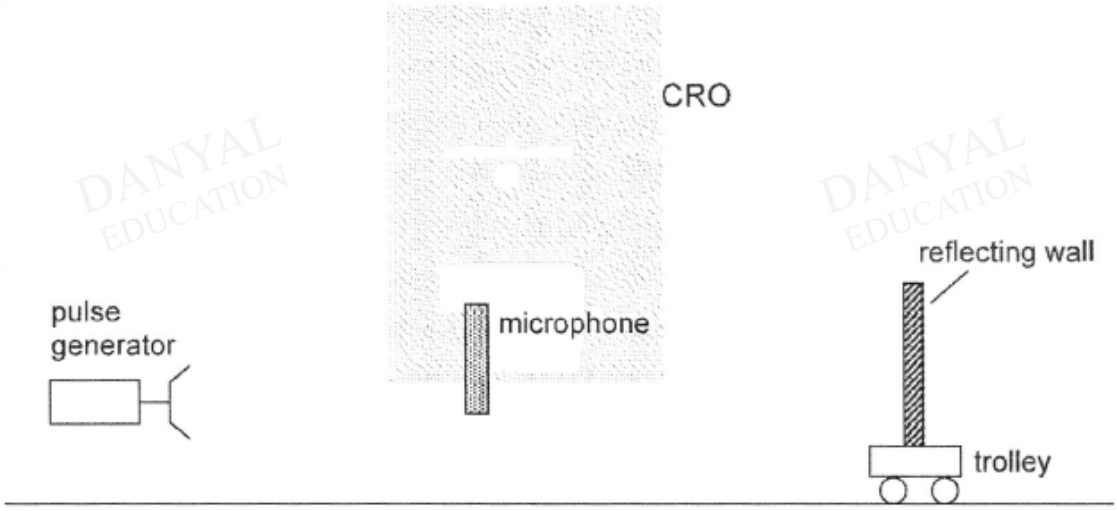

Fig. 7.1

An ultrasonic pulse is generated by the pulse generator. The CRO is turned on at the same time and a trace consisting of two pulses is obtained on the CRO as shown in Fig. 7.2. The time-base of the CRO is set at 10 ms/division.

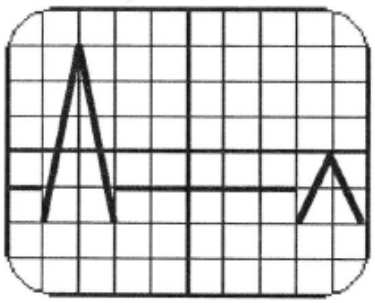

Fig. 7.2

(a) Ultrasound is a longitudinal wave. Explain what is meant by this statement.

.....

..... [1]

(b) If the speed of sound is 330 m/s, determine the distance between the microphone and the reflecting wall.

distance = ... [2]

(c) The reflecting wall is now moved closer to the microphone.

(i) Describe two changes that would occur to the trace on the CRO.

.....

.....

.....

..... [2]

(ii) Suggest why the setup could not be used if the distance between the microphone and the wall is less than 1 m.

.....

..... [1]

Q2

Fig. 3.1 shows the positions of particles of a medium at a particular instant when a sound wave, travelling from left to right, passes through the medium. Before the wave arrived, the particles were equally spaced at their original undisturbed positions as shown by the vertical lines.

Fig. 3.1

(a) State the type of wave formed in Fig. 3.1. Explain your answer.

_____

_____

_____ [2]

(b) Given that Fig. 3.1 is drawn to full scale, determine the amplitude and the wavelength. (Give your answers to 1 d.p.)

amplitude = _____ [1]

wavelength = _____ [1]

(c) If the sound has a frequency of 100 Hz, calculate the speed of the wave.

speed = _____ [2]

(d) Calculate the time taken for the compression at Q to move to the position at R.

time = _____ [1]

(e) Describe how the movement of the particle at point P will change (if any) when

(i) A softer sound passes through it.

_____ [1]

(ii) A lower pitch sound passes through it.

_____ [1]

Q3

Fig. 5.1 shows a setup using ultrasound to detect flaws in welding. A pulse sent by the transmitter reflects from the other end of the metal into the receiver. Fig. 5.2 shows one normal C.R.O. signal display and two abnormal displays. The speed of ultrasound through the piece of metal is 3200 m/s.

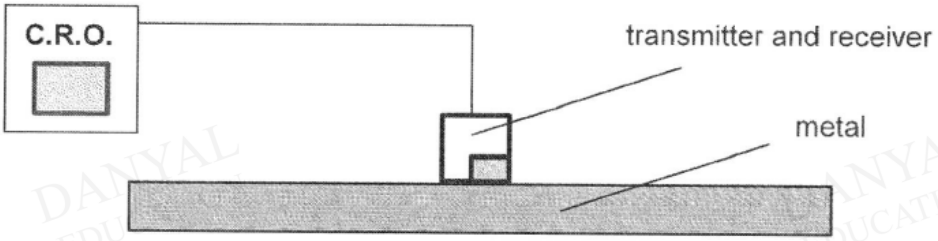

Fig. 5.1

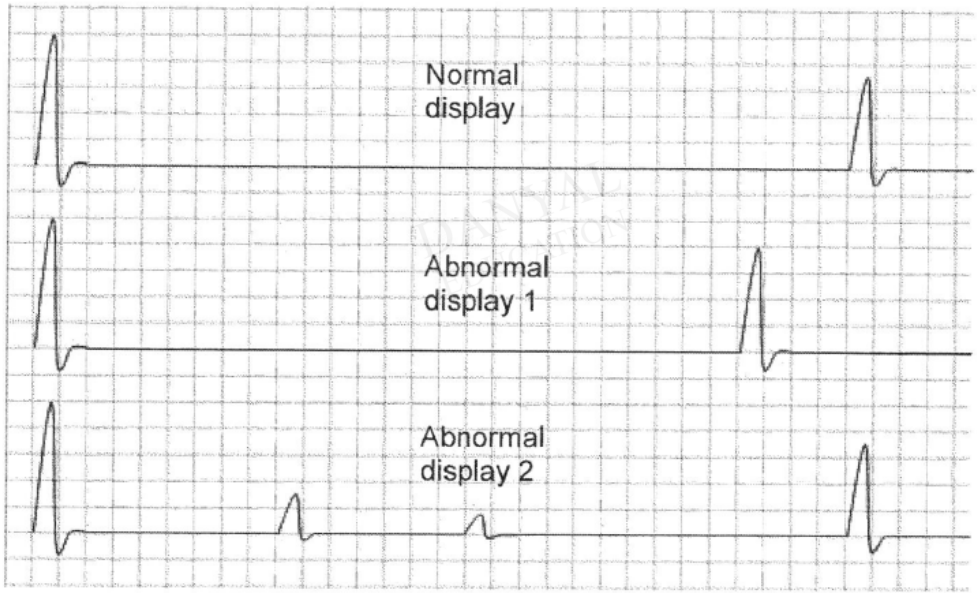

Fig. 5.2

(a) For the normal display, the time interval between the transmitted and received pulse is 30×10^{-6} s.

Calculate the thickness of the piece of metal.

thickness = ...[1]

(b) Suggest a possible reason for the abnormalities in

display 1,

.....

.....[1]

display 2.

.....

.....[1]

(c) Explain why a received pulse will have a lower amplitude than the transmitted pulse.

.....[1]

Q4

A robotic vacuum cleaner uses ultrasonic waves to detect obstacles and avoid them as it cleans the floor.

Fig 5.1 shows how it sends off a pulse of ultrasound and detects the reflected ultrasound (echo) pulse off the obstacle.

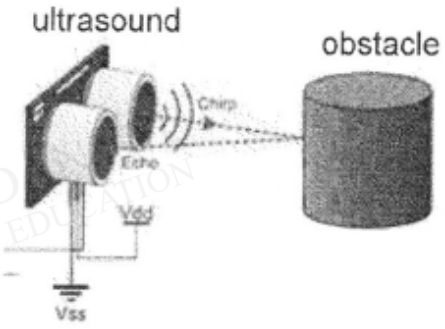

Fig 5.1

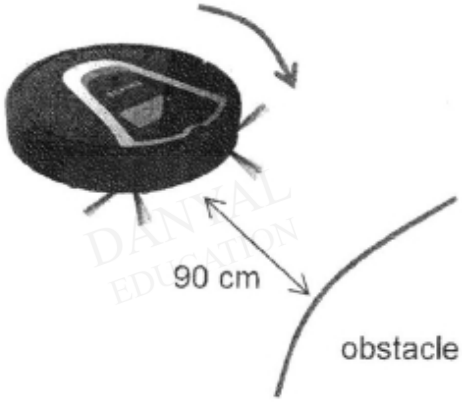

Fig 5.2

Fig 5.2 shows how the robot is programmed to turn right when it detects an obstacle 90 cm away.

(a) Calculate the time interval taken in ms for the robot to detect an object 90 cm away. Assume the speed of ultrasound to be 330 m/s.

time interval = _____ ms [1]

(b) An engineer uses another ultrasound sensor to check on the actual performance of the robot. The sensor also works by sending a sound wave to the obstacle and recording the time for the reflected pulse to come back. The voltage output of the sensor is connected to an oscilloscope.

In Fig 5.3, pulse A represents the first ultrasound pulse sent out while pulse B represents the echo pulse.

The time-base of the oscilloscope is set at 0.70 ms/cm.

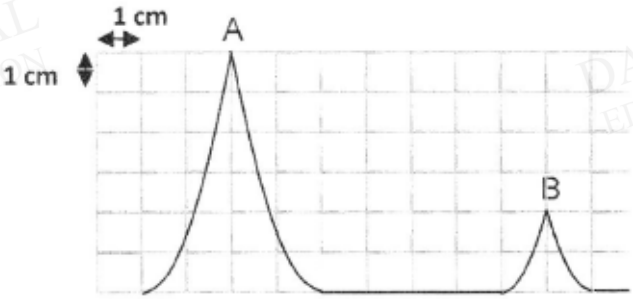

Fig 5.3

Calculate the distance between the robot and the obstacle when it turns if the robot performs based on the oscilloscope results.

distance = _____ [2]

(c) Suggest a possible reason for the difference in the programmed distance of 90 cm and the actual distance in (b). This difference in distance is more evident when the mass of the robot is higher.

_____

_____ [1]

Q5

Fig. 7.1 shows how ultrasound is used to produce an image of the heart.

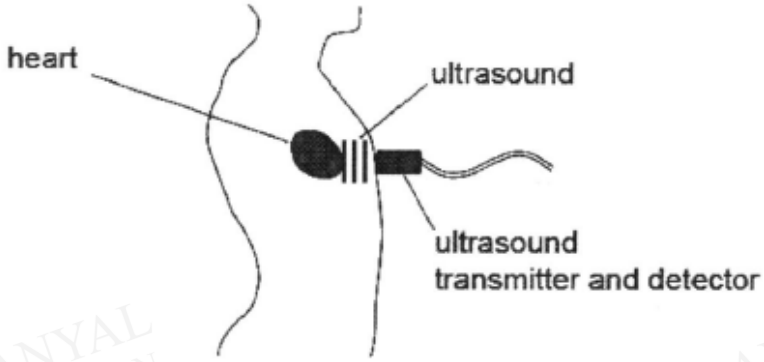

Fig. 7.1

(a) Define *ultrasound*.

.....

..... [1]

(b) The ultrasound has a wavelength of 1.2 mm. The speed of the ultrasound in the human body is 1500 m/s.
Calculate the frequency of the ultrasound.

frequency = ... [2]

(c) Explain how the vibrations of the transmitter produce waves of ultrasound between the transmitter and the heart.

.....

.....

..... [2]

Answers

Sound Test 1.0

Q1

a	Ultrasound travels in a direction parallel to the direction of vibration of the medium particles. [B1]

b	Time taken for sound to travel from microphone to wall and back = 7 x 0.01 = 0.07 s [M1] 2d / 0.07 = 330 d = 11.6 m [A1]
ci	The second pulse on the CRO will be positioned nearer to the first pulse [B1] and has a larger amplitude. [B1]
cii	The two pulses on the CRO will overlap each other / cannot be distinguished from each other. [A1]

Q2

3(a)	Longitudinal waves. The particles vibrate parallel to the direction of the wave motion.	[1] [1]
(b)	Amplitude = 0.8 cm Wavelength = 11.7 cm	[1] [1]
(c)	v = 100 x 0.117 = 11.7 m/s or 1170 cm/s [allow ecf]	[1] [1]
(d)	T = 1 / f = 1 / 100 = 0.010 s. Time taken for compression to move = 0.010 / 2 = 0.0050 s [allow ecf]	[1]
(e) (i)	Particle P will <u>vibrate</u> from its rest position with a <u>shorter maximum displacement</u>. [or shorter amplitude]	[1]
(ii)	Particle P will <u>oscillate less times in one second</u>. [or frequency decreases]	[1]

Q3

a	speed = total distance / total time 3200 = (2 x thickness) / (30×10^{-6}) Thickness = 0.048 m	B1
b	display 1: metal is too thin display 2: two cracks/cavities in metal	B1 B1
c	-Energy is absorbed by the metal / energy is lost to surroundings Or any appropriate answer that shows waves reflect in different directions and not all return to receiver	B1

Q4

5a	Time interval = distance/speed = (2 X0.90) / 330 = 5.45 X 10^{-3} = 5.5 ms	1
5b	Distance = speed X time time = ½ (7 X 0.70) ms = 2.45 ms Distance = speed X time = 330 X 2.45 X 10^{-3} = 0.81 m	 1 1
5c	A higher mass leads to a higher inertia. When the robot is programmed to stop (or wheels stop moving), the higher inertia makes the robot harder to stop and it continues to travel, hence distance to obstacle is less (0.81 m instead of ideal 0.90 m)	1

Q5

(a)	Sound with frequencies above / beyond the upper limit of the human range of audibility / 20 kHz.	[1]
(b)	$v = f\lambda \Rightarrow f = v/\lambda = 1500 / 1.2 \times 10^{-3}$ = 1 250 000 Hz (or **1.25 MHz**)	[1]: W & C/F [1]: A & U
(c)	• (Vibration of transmitter causes) body cells / tissues to vibrate parallel to direction of travel of sound wave • Forming regions of compressions and rarefactions	[1] [1]