Properties of Waves

Questions

Q1.

Four students and their teacher do an experiment to measure the speed of sound in air.

The teacher stands at a distance and fires a starting pistol into the air.
The students see the flash when the pistol is fired.
They measure the time from when they see the flash to when they hear the bang.

A student drew a diagram of the arrangement as shown in Figure 7.

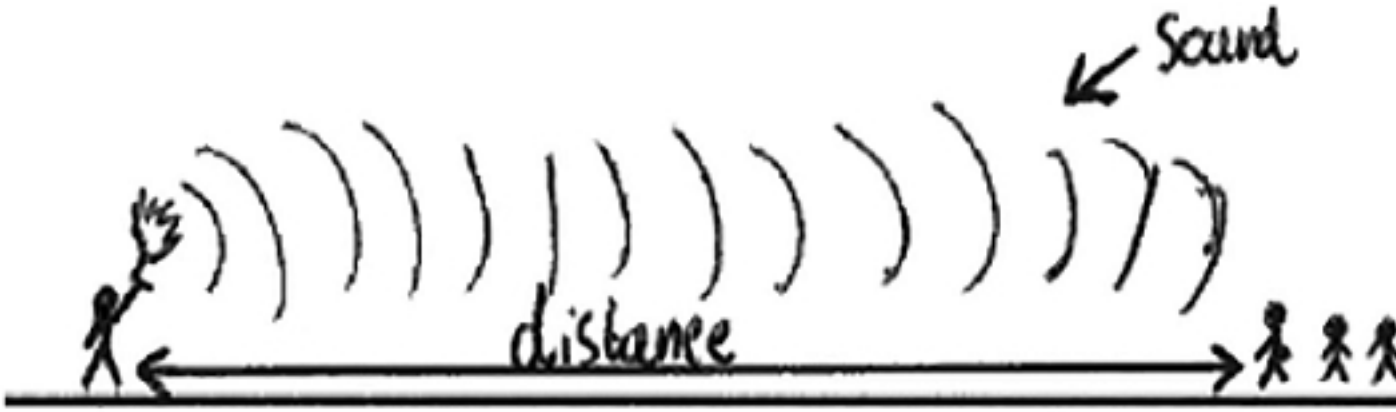

Figure 7

The students obtained a value of 240 m/s for the speed of sound.

The accepted value, in a science data book, is 343 m/s.

(i) Calculate the difference between the students' value and the accepted value as a percentage of the accepted value.

(2)

percentage difference = ... %

(ii) When the distance was 100 m, the students measured the following times:

0.43 s 0.35 s 0.50 s 0.38 s

Explain why their times vary so much.

(2)

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(iii) Explain one way the students might improve this experiment.

(2)

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(Total for question = 6 marks)

Q2.

A radio station transmits on 97.4 MHz.

To receive the waves an aerial needs a length equal to half the wavelength of the radio waves being transmitted.
Calculate the length of the aerial needed.

The speed of the radio waves is 3.00 × 108 m / s.

(3)

length of aerial = ... m

(Total for question = 3 marks)

Q3.

The speed of sound in air is 300 m/s.

The speed of sound in water is 1500 m/s.

Calculate the ratio of the speed of sound in air to the speed of sound in water.

(2)

ratio of speed of sound in air to the speed of sound in water =
.....

(Total for question = 2 marks)

Q4.

A water wave has a wavelength of 0.25 m and a frequency of 1.5 Hz.

Calculate the wave speed.

(2)

wave speed = ... m/s

(Total for question = 2 marks)

Q5.

Figure 12 shows part of a wave.

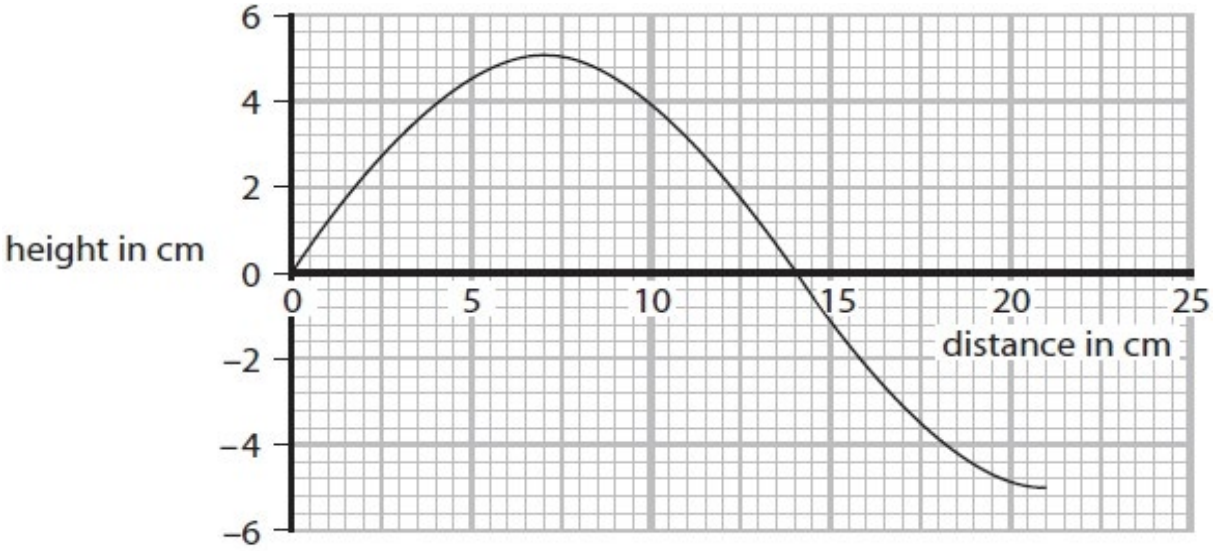

Figure 12

Use data from Figure 12 to calculate the wavelength of the wave.

(2)

wavelength = ... cm

(Total for question = 2 marks)

Q6.

Sound waves are longitudinal waves.

Water waves are transverse waves.

Describe the difference between longitudinal waves and transverse waves.

(3)

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(Total for question = 3 marks)

Q7.

Figure 8 represents a sound wave coming from a loudspeaker and shows the effects on particles of the air at one instant in time.

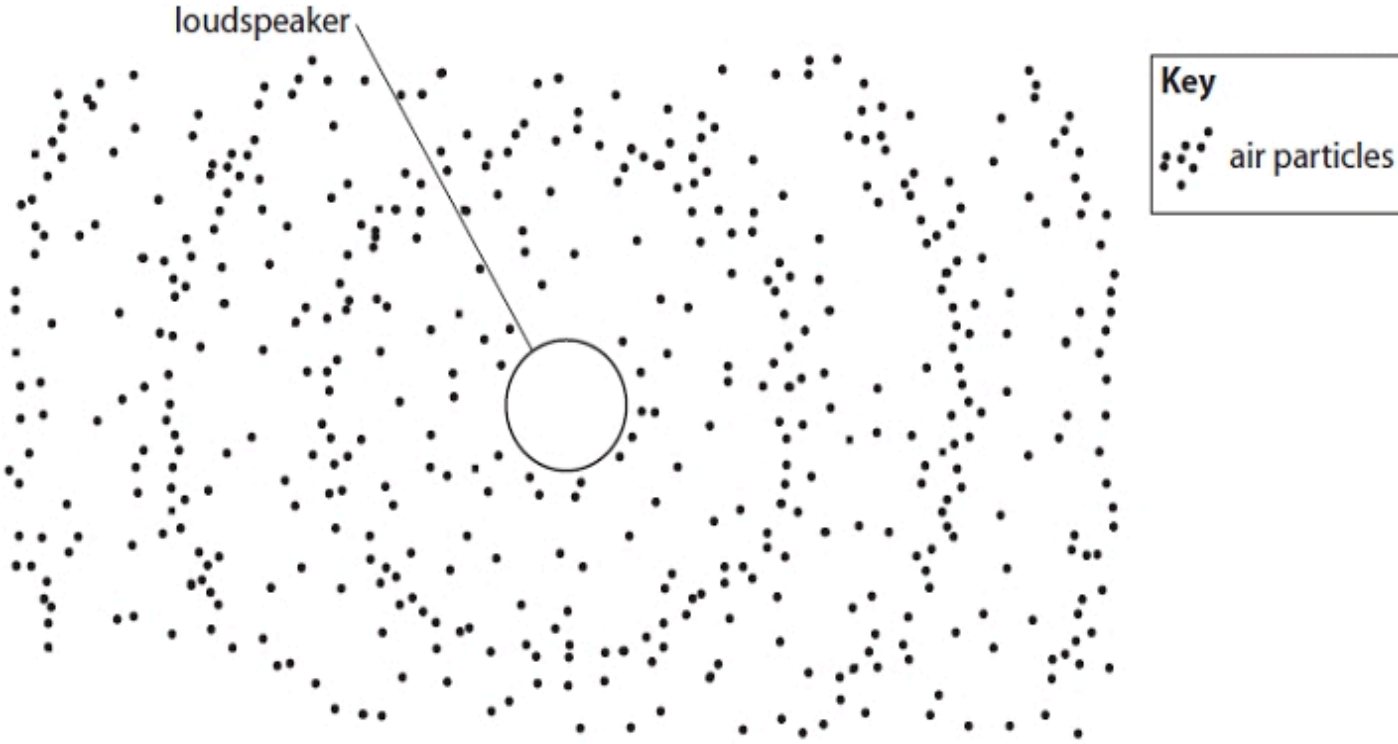

Figure 8

(i) Draw and label a distance of one wavelength in Figure 8.

(1)

(ii) Describe the motion of the particles as the wave travels through the air.

(2)

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(Total for question = 3 marks)

Q8.

Figure 11 shows a large tank of water.

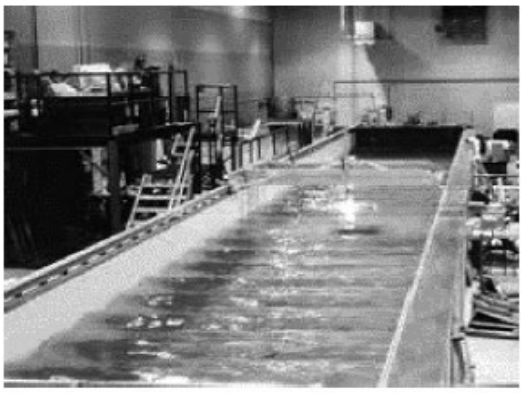

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Figure 11

The tank of water is used to study water waves.

Figure 13 shows part of the inside of the Earth below the surface.

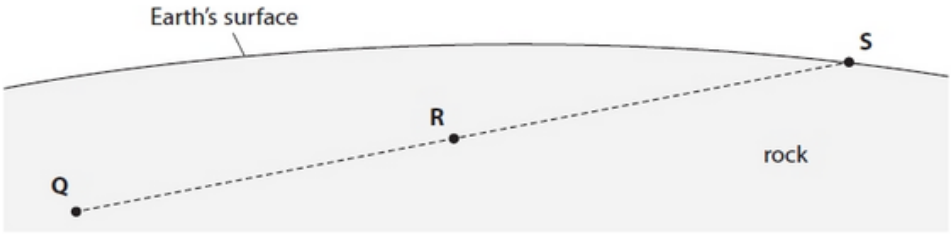

Figure 13

An earthquake starts at Q.

A seismic wave travels from Q to S.

The seismic wave is a longitudinal wave.

The frequency of the seismic wave is 12Hz.

A technician measured the frequency of the water wave in Figure 11 by counting how many waves passed him in 15 s.
Explain why this would not be a suitable method for measuring the frequency of the seismic wave in Figure 13.

(2)

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(Total for question = 2 marks)

Q9.

(i) Figure 2 shows a student sitting on the shore of a lake watching ripples on the surface of the water moving past a toy boat.

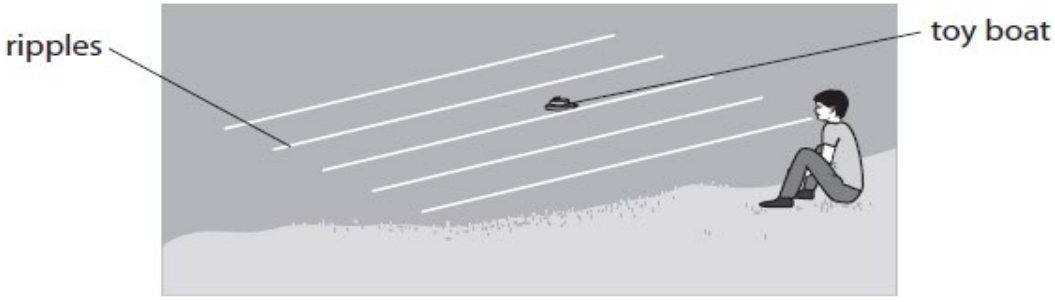

Figure 2

The student has a stopwatch.
Describe how the student could determine the frequency of the ripples on the lake.

(3)

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(ii) The speed of a water wave is 1.5 m/s.

The frequency of the wave is 0.70 Hz.
Calculate the wavelength of this wave.
Use the equation

$$v = f \times \lambda$$

(2)

wavelength = ... m

(iii) Water waves are transverse waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

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.....

.....

.....

(Total for question = 7 marks)

Q10.

The speed of light is 3.0 × 108 m/s.

The wavelength of yellow light is 5.8 × 10−7 m.

Calculate the frequency of yellow light.

State the unit.

Use the equation

$$\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$$

(3)

frequency = ... unit .....

(Total for question = 3 marks)

Q11.

Figure 11 shows a large tank of water.

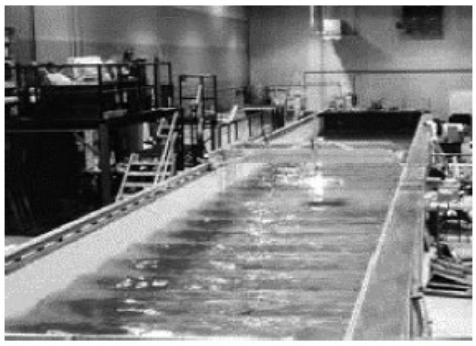

Figure 11

The tank of water is used to study water waves.

(i) Water waves are transverse waves.

Give another example of a transverse wave.

(1)

.....

(ii) Figure 12 shows a side view of part of the tank.

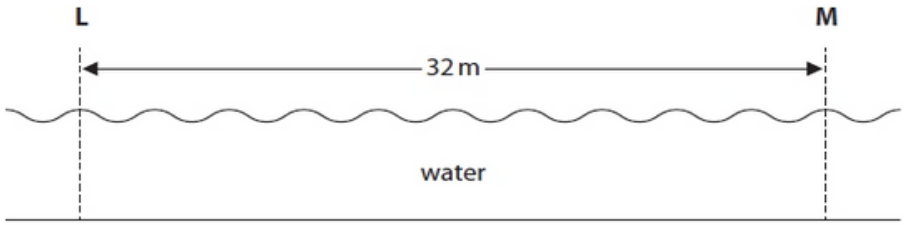

Figure 12

A water wave is moving from L to M.
Calculate the wavelength of the wave.

(2)

wavelength = ... m

(iii) A technician stands at the side of the tank.

He counts the peaks of the waves as they pass him.
12 peaks pass the technician in a time of 15 s.
Calculate the frequency of the wave.

(2)

frequency = ... Hz

(Total for question = 5 marks)

Q12.

Figure 2 shows water waves spreading out from a source.

A student measures the wavelength of the waves.

He uses a ruler to measure the distance from one crest to the next crest.

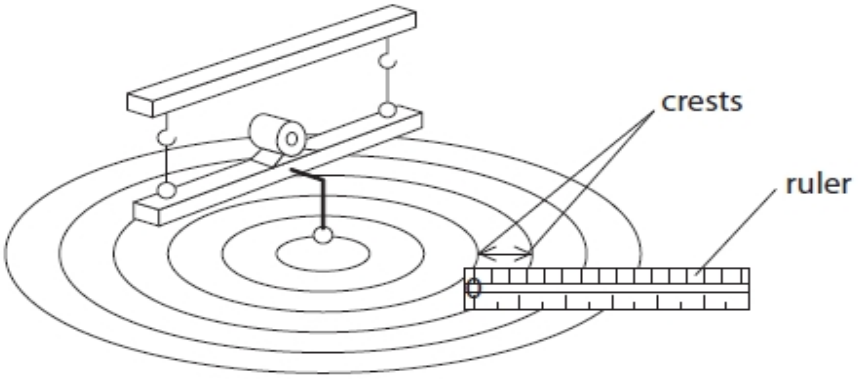

Figure 2

Explain how to improve the student's method for measuring the wavelength.

(2)

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.....

(Total for question = 2 marks)

Q13.

A sound wave in air travels a distance of 220 m in a time of 0.70 s.

(i) State the equation linking speed, distance and time.

(1)

(ii) Calculate the speed of the sound wave in air.

(2)

wave speed = ... m/s

(Total for question = 3 marks)

Q14.

Sound travels slower in cold air than it does in warm air.

The equation relating the speed of sound in air to the density of the air is

$$\text{speed of sound} = \frac{K}{\sqrt{(\text{density})}} \qquad \text{where K is a constant.}$$

The table in Figure 10 gives some data about the speed of sound in air and the density of air.

	speed of sound in m/s	density of air in kg / m³
in cold air	331	1.29
in warm air		1.16

Figure 10

Use the equation and the data in the table in Figure 10 to calculate the speed of sound in warm air.
Give your answer to an appropriate number of significant figures.

(3)

speed of sound in warm air = ... m/s

(Total for question = 3 marks)

Q15.

Figure 9 is a diagram of a water wave.

A cork is floating on the water.

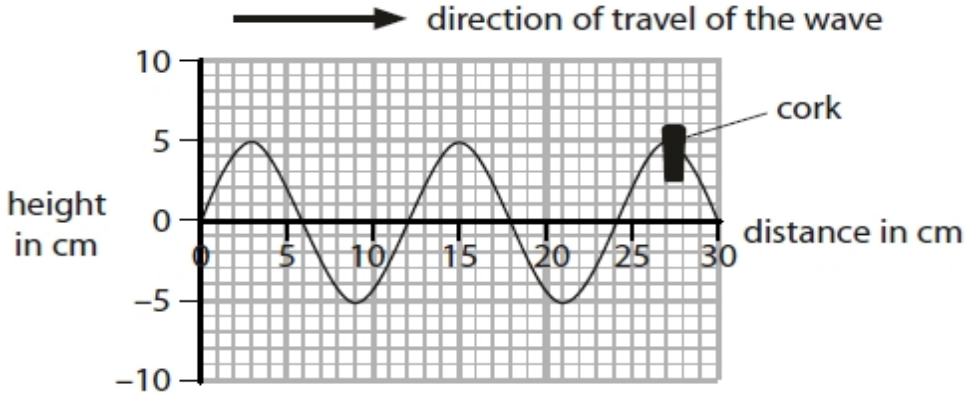

Figure 9

(i) Use the scale on the diagram to measure the wavelength of the wave.

(2)

wavelength = ... cm

(ii) Describe the motion of the cork.

You should include how the cork moves relative to the direction of travel of the wave.

(2)

.....

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.....

(Total for question = 4 marks)

Mark Scheme – Properties of Waves

Q1.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) % difference = $\frac{(240 - 343)}{343} \times 100$ evaluation (1) (-) 30 (%)	 OR 343 – 240 in numerator award full marks for the correct answer without working allow 1 mark for division by 240 yielding 43% allow one mark for $\frac{240}{343} \times 100 = 70\ \%$	(2)

Question number	Answer	Additional guidance	Mark
(ii)	explanation linking any two of: reaction time is significant (with 0.5s or less) (1) the reaction time will be different for each of the students (1) effects on reaction times (1) students are at different distances (from starting pistol) (1) anticipation of flash / bang (1)	 accept reaction time is large compared with travel time differences in perception / acuity of light and sound	(2)

Question number	Answer	Additional guidance	Mark
(iii)	explanation linking: use a (much) longer distance **OR** use electronic timer (1) with effect (1) reduces/eliminates the significance/impact of the reaction time **OR** gives a more manageable time to measure	all stand the same distance from the starting pistol (1)	**(2)**

Q2.

Question number	Answer	Additional guidance	Mark
	recall **and** rearrangement (1) $\lambda = \frac{v}{f}$ evaluation (1) 3.08 (m) (so) length of aerial = 1.54 m (1) check working $\frac{3\times10^8}{2} = 1.5 \times 10^8$ gets only 1 mark for ecf	$\frac{3.0\ (\times 10^8)}{97.4\ (\times 10^6)}$ accept 3.1 (m) award 1 mark for wavelength that rounds to 3.1 to any other power of 10 independent mark. allow ECF from candidate's wavelength accept 1.5 (m) award 2 marks for 1.5 to any other power of 10 award full marks for the correct answer without working Allow 1.46 rounded to 1.5 for 1 mark only if it is ecf from mp2	**(3)**

Q3.

Question Number	Answer	Additional guidance	Mark
	substitution (1) 300 : 1500 evaluation (1) 1:5	 $\frac{300}{1500}$ 0.2 OR $\frac{1}{5}$ ignore any units award full marks for the correct answer without working allow 1 mark for either 5:1 OR 5	**(2)**

Q4.

Question Number:	Answer	Additional guidance	Mark
	recall and substitution (1) (v =) 0.25 x 1.5 evaluation (1) 0.38 (m/s)	 accept 0.375 or 0.37 (m/s) accept 37.5, 37 or 38 for 1 mark only award full marks for the correct answer without working	**(2)**

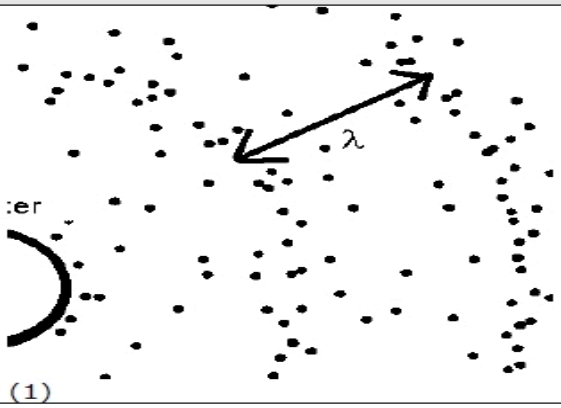
Q5.

Question number	Answer	Additional guidance	Mark
	uses data taken from x axis (1) 28(cm) (1)	award full marks for correct answer without working	**(2)** **AO3**

Q6.

Question Number	Answer	Additional guidance	Mark
	a description to include: • longitudinal – (vibrations) parallel to (direction of travel) (1) • transverse – (vibrations) at right angles to (direction of travel) (1) • (connection between) direction of travel with (direction of) vibrations (1)	back and forth (oscillations)/ compressions or rarefactions up and down (oscillations)	**(3)** AO 1 1

Q7.

Question number	Answer	Additional guidance	Mark
(i)	 (1)	any similar distance labelled wavelength / λ between the equivalent of 2 consecutive compressions	(1)

Question number	Answer	Additional guidance	Mark
(ii)	description including any two from: particles vibrate / oscillate/ move backwards and forwards (1) along a radius/ parallel to direction of travel/ energy transfer (1) about mean /fixed positions (1)	 allow air for particles in same direction as wave allow one mark for 'sound is a longitudinal wave' if no other mark awarded	(2)

Q8.

Question number	Answer	Additional guidance	Mark
	an explanation to include two from: waves cannot be seen (on arrival) (1) person will need another way of detecting the waves (1) (as) a person cannot count to 12 in one second / at a rate of 12 per second (1) frequency too high (1)	 idea of coming too fast to count / easy to lose count	(2)

Q9.

Question number	Answer	Additional guidance	Mark
(i) CS1	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = number of waves / time (1)	 ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	(3) AO1

Question number	Answer	Additional guidance	Mark
(ii) CS1	substitution (1) $1.5 = 0.7 \times \lambda$ rearrangement and evaluation 2.1(4) m	 $\frac{1.5}{0.7}$ allow $\frac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. $\lambda = v/f$ scores 1 mark	(2) AO2

Question number	Answer	Additional guidance	Mark
(iii) CS1	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal - (oscillations) in same direction as wave (travel) (1)	 up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	(2) AO1

Q10.

Question Number	Answer	Additional guidance	Mark
	substitution (1) $\frac{3.0 (\times 10^{8})}{5.8 (\times 10^{-7})}$ evaluation (1) 5.2×10^{14} unit (1) Hz	 answers that round to 5.2×10^{14} award 2 marks for a correct answer without working allow 1 mark for answers that round to 5.2 to any power of ten independent mark accept hz or s^{-1} or per sec(ond) or hertz accept kHz, MHz etc with correct power (10^{11} kHz, 10^{8} MHz)	**(3)** AO 2 1

Q11.

Question number	Answer	Additional guidance	Mark
(i)	**one** from: radio(wave) (1) micro(wave) (1) infrared (1) visible (light) (1) ultraviolet (1) X(-ray) (1) gamma (rays) (1) electromagnetic/em wave(s) seismic **S**(-wave)	Do not credit if sound waves also mentioned γ earthquake **S**(-wave)	**(1)**

Question number	Answer	Additional guidance	Mark
(ii)	$\frac{32}{\text{number of wavelengths}}$ (1) $\frac{32}{10}$ evaluation (1) 3.2 (m)	 accept 9 or 11 for 10 no ecf from mp1 3.6 (3.5r) or 2.9(1) award full marks for the correct answer without working	(2)

Question number	Answer	Additional guidance	Mark
(iii)	substitution (1) $\frac{12}{15}$ evaluation (1) 0.8(0) (Hz)	 award full marks for the correct answer without working	(2)

Q12.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: • measure across more than one (wavelength) (1) • divide by the number of wavelengths (1)	 use a more accurate device (finer divisions) use a camera / picture/strobe(light) (so the waves are not moving) count the number of wavelengths must be talking about **measuring**, NOT changing the wavelength etc.	(2) AO 3 3b

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	recall speed = $\frac{\text{distance}}{\text{time}}$	accept any correct rearrangement or use of s, d and t may use v for speed and x for distance ignore use of triangles	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
(ii)	substitution (1) (speed) = $\frac{220}{0.7(0)}$ evaluation (1) 310 (m/s)	allow ecf from part (i) for this mark only allow any numbers that round to 310 e.g. 314 award full marks for the correct answer without working	(2) AO 2 1

Q14.

Question Number	Answer	Additional guidance	Mark
	using cold row: evaluate (K=)376 (1) using warm row: substitute K and ρ $\frac{376}{\sqrt{1.16}}$ OR 349.10.... (1) 349 (m/s) to 3 sig figs (1)	$\frac{\text{other K from earlier calculation}}{\sqrt{1.16}}$ any answer to 3 sig figs 349.10... scores MP1 and MP2 award full marks for the correct answer without working	(3)

Q15.

Question Number	Answer	Additional guidance	Mark
(i)	evidence of use of scale on horizontal distance axis only (1) 12 (cm) (1)	may be seen on the diagram range 11.5 to 12.5 (cm) award full marks for the correct answer without working 6 (cm) or 30(cm) scores 1 mark (evidence of use)	**(2)**

Question Number:	Answer	Additional guidance	Mark
(ii)	a description to include: moves up and down (1) at right angles / normal / perpendicular to (direction of) wave/travel (1)	independent marking points vertical (oscillations) not in the (direction of) wave / travel accept 'transverse wave' for 2nd MP	**(2)**