Topic 9 – Sound waves

1. O/N/14/1[1]

(b) Fig. 5.1 shows an electric bell ringing in a sealed glass chamber containing air.

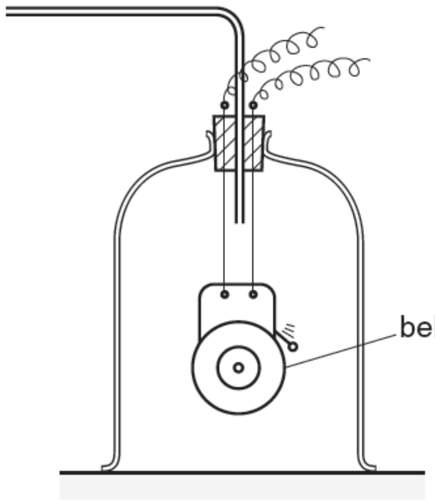

Fig. 5.1

A student hears the bell ringing. The air is then removed from the chamber.

State and explain any change in the sound heard by the student.

....

....

....

....[2]

[Total: 8]

2. M/J/14/1[2]

(a) Draw a straight line from each quantity on the left-hand side to a speed on the right-hand side which is typical for that quantity.

	30 m/s
speed of sound in gas	300 m/s
	3000 m/s
speed of sound in solid	30 000 m/s
	300 000 m/s

[2]

(b) Explain why sound waves are described as *longitudinal*.

....

.... [2]

(c) Fig. 8.1 shows how the displacement of air molecules, at an instant of time, varies with distance along the path of a sound wave.

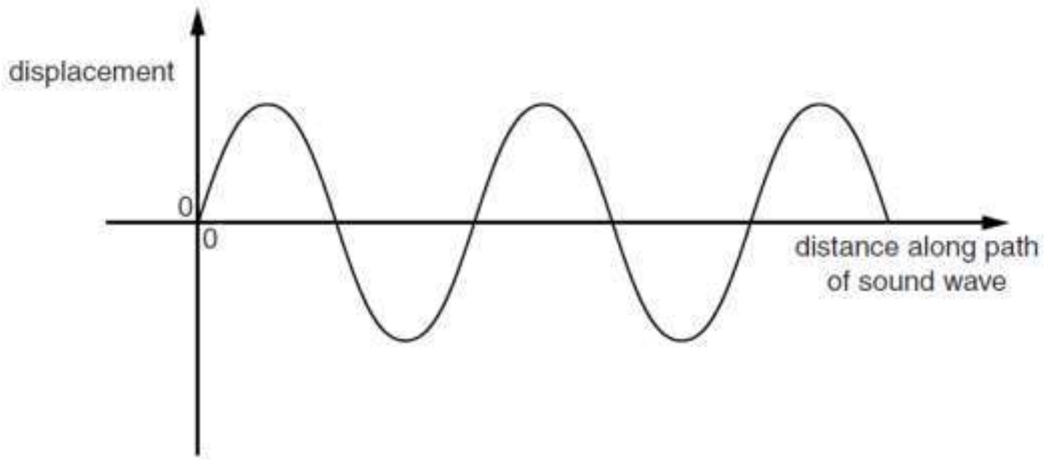

Fig. 8.1

(i) On Fig. 8.1, sketch two cycles of a sound wave that has a shorter wavelength **and** a greater amplitude. [2]

(ii) State **two** changes in the sound heard from this wave compared with the original wave.

1. ....

2. ....

[2]

[Total: 8]

3. O/N/2013/2[3]

(a) Draw a straight line from each wave to the most appropriate speed on the right.

wave	speed
	15 m/s (1.5×10 m/s)
	300 m/s (3×10^2 m/s)
light in air	1500 m/s (1.5×10^3 m/s)
sound in air	1 500 000 m/s (1.5×10^6 m/s)
sound in water	300 000 000 m/s (3×10^8 m/s)
	1 500 000 000 m/s (1.5×10^9 m/s)

[3]

(b) Fig. 6.1 shows a railway-line testing-team checking a continuous rail of length 120 m. The diagram is not to scale.

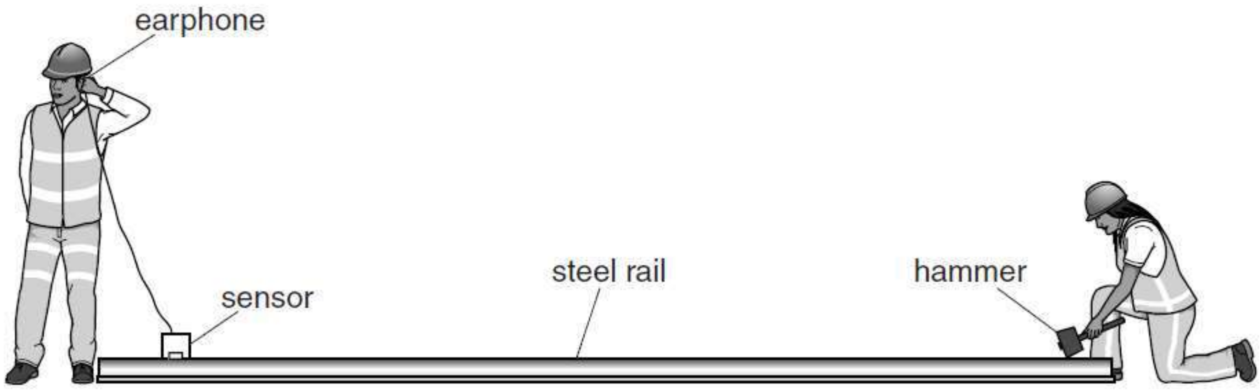

Fig. 6.1 (not to scale)

One tester strikes one end of the rail with a hammer. The other tester hears the sound transmitted through the air and transmitted through the rail. He hears the two sounds at different times.

The speed of sound in steel is 5000 m/s.

Calculate the time difference, using your value from **(a)** for the speed of sound in air.

time difference = ... [4]

[Total: 7]

4. M/J/2013[4]

(a) State the range of frequencies of sound which can be heard by a healthy human ear.

....[1]

(b) Compressions and rarefactions occur along the path of sound waves.

State, in terms of the behaviour of molecules, what is meant by

(i) a *compression*,

....

....

(ii) a *rarefaction*.

....

....
[2]

(c) State the effect on what is heard by a listener when there is

(i) an increase in the amplitude of a sound,

....[1]

(ii) a decrease in the wavelength of a sound.

....[1]

(d) A student carries out an experiment to find the speed of sound in air.

He stands facing a high cliff and shouts. He hears the echo 1.9 s later.

He then walks 250 m further away from the cliff and shouts again, hearing the echo 3.5 s later.

Calculate the speed of sound given by this experiment.

speed = ...[3]

[Total: 8]

5. O/N/2011/1[5]

(a) Fig. 6.1 shows the position of layers of air, at one moment, as a sound wave of constant frequency passes through the air. Compressions are labelled C. Rarefactions are labelled R.

Fig. 6.1

(i) State how Fig. 6.1 would change if

1. the sound had a higher frequency,

....[1]

2. the sound were louder.

....

....

....[2]

(ii) On Fig. 6.1, draw a line marked with arrows at each end to show the wavelength of the sound. [1]

(b) In an experiment to measure the speed of sound in steel, a steel pipe of length 200 m is struck at one end with a hammer. A microphone at the other end of the pipe is connected to an accurate timer. The timer records a delay of 0.544 s between the arrival of the sound transmitted by the steel pipe and the sound transmitted by the air in the pipe.

The speed of sound in air is 343 m/s. Calculate the speed of sound in steel.

speed of sound in steel = ...[3]

[Total: 7]

6. O/N/2011/2[6]

(a) State an approximate value for

(i) the speed of sound in air, ...

(ii) the speed of light in air. .... [2]

(b) Use your value from **(a)(i)** to calculate the frequency of a sound wave that has a wavelength of 1.2 m.

frequency = ... [2]

(c) A meteorologist observes an approaching thunderstorm and records a time difference of 4.8 s between seeing a lightning flash and hearing the thunder that follows.

(i) Calculate the distance of the thunderstorm from the meteorologist.

distance = ...

(ii) State an assumption you made when calculating this distance.

....

....

....
[2]

[Total: 6]

7. O/N/2011/2[7]

Fig. 8.1 shows a loudspeaker cone oscillating to produce sound waves.

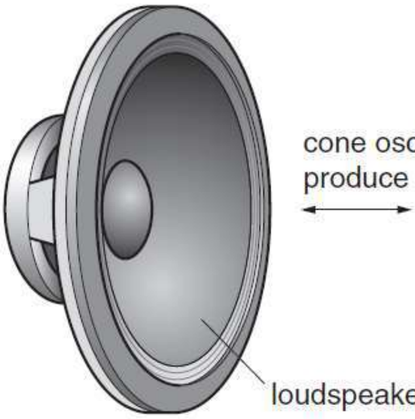

Fig. 8.1

(a) As the sound wave passes a point, it produces regions of higher and lower pressure. State the names of these regions.

higher pressure ....

lower pressure .... [2]

(b) Describe how the movement of the loudspeaker cone produces these regions of different pressure.

higher pressure ....

....

lower pressure ....

.... [2]

(c) State the effect on the loudness and pitch of the sound from the loudspeaker when

(i) the amplitude increases but the frequency of the sound stays the same,

loudness ....

pitch ....

(ii) the amplitude stays the same but the frequency increases.

loudness ....

pitch ....

[2]

[Total: 6]

8. M/J/2010/1[8]

During a thunderstorm, thunder and lightning are produced at the same time.

(a) A person is some distance away from the storm.

Explain why the person sees the lightning before hearing the thunder.

....

....

.... [1]

(b) A scientist in a laboratory made the following measurements during a thunderstorm.

time from start of storm / minutes	0.0	2.0	4.0	6.0	8.0	10.0
time between seeing lightning and hearing thunder / s	3.6	2.4	1.6	2.4	3.5	4.4

Fig. 7.1

(i) How many minutes after the storm started did it reach its closest point to the laboratory?

.... [1]

(ii) How can you tell that the storm was never immediately over the laboratory?

.... [1]

(iii) When the storm started, it was immediately above a village 1200 m from the laboratory.

Using this information and information from Fig. 7.1, calculate the speed of sound.

speed of sound = ... [2]

(iv) State the assumption you made when you calculated your answer to **(b)(iii)**.

.... [1]

(c) Some waves are longitudinal; some waves are transverse.

Some waves are electromagnetic; some waves are mechanical.

Put ticks (✓) in the table below to indicate which of these descriptions apply to the light waves of the lightning and the sound waves of the thunder.

	light waves	sound waves
longitudinal		
transverse		
electromagnetic		
mechanical		

[3]

[Total: 9]

9. M/J/2010/2[9]

A disused railway line has a length of 300 m. A man puts his ear against one end of the rail and another man hits the other end with a metal hammer, as shown in Fig. 7.1.

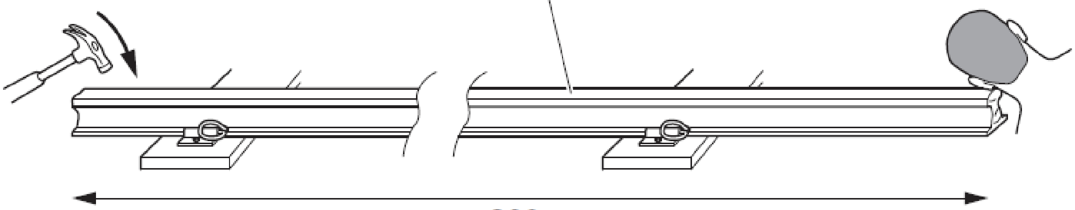

Fig. 7.1

(a) **(i)** State an approximate value for the speed of sound in air.

.... [1]

(ii) Sound travels at 5000 m/s in steel.

Calculate the time it takes for the sound to travel along the rail.

time taken = ... [2]

(b) The man with his ear to the railway line actually hears two sounds from the hammer, separated by a short interval.

Explain why he hears two sounds.

....

....

....

.... [2]

[Total: 5]

10. O/N/2007[10]

(a) In the space below, draw a diagram to represent a sound wave.

On your diagram, mark and label

(i) **two** consecutive compressions and **two** consecutive rarefactions,

(ii) the wavelength of the wave.

[3]

(b) Fig. 7.1 shows part of the electromagnetic spectrum.

Fig. 7.1

(i) On Fig. 7.1, label the positions of γ-rays, visible light waves and radio waves. [1]

(ii) State which of the three types of wave in **(i)** has the lowest frequency.

.... [1]

(iii) State the approximate value of the speed in air of radio waves.

.... [1]

[Total: 6]

11. M/J/2007[11]

Two students are asked to determine the speed of sound in air on the school playing fields.

(a) List the apparatus they need.

....

....

.... [1]

(b) List the readings that the students need to take.

....

....

.... [1]

(c) State how the speed of sound is calculated from the readings.

.... [1]

(d) State one precaution that could be taken to improve the accuracy of the value obtained.

....

.... [1]

(e) The table gives some speeds.

speed/ m/s	speed of sound in air	speed of sound in water
10		
100		
1000		
10 000		

Place a tick in the table to show the speed which is closest to

(i) the speed of sound in air,

(ii) the speed of sound in water.

[2]

[Total: 6]

12. M/J/2007[12]

Fig. 7.1 shows how the air pressure at one instant varies with distance along the path of a continuous sound wave.

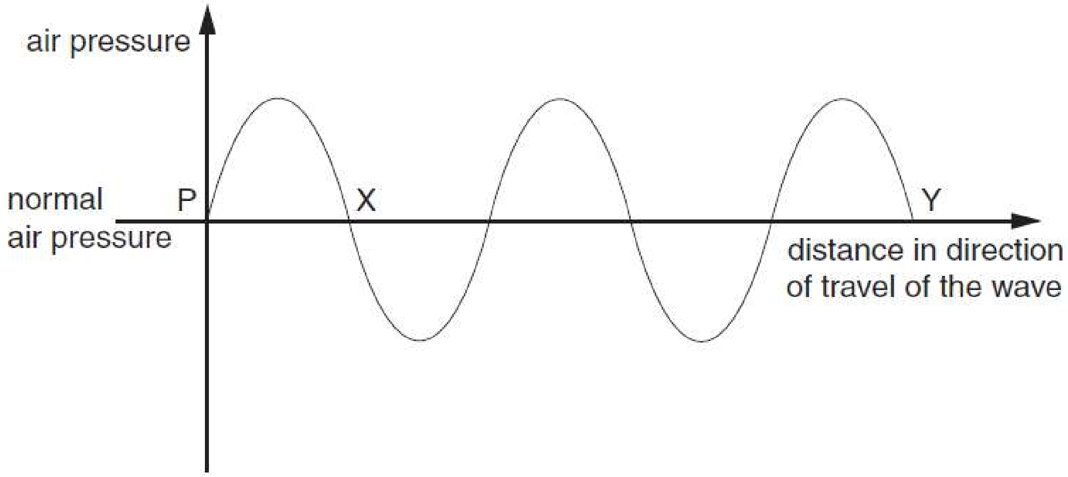

Fig. 7.1

(a) What type of waves are sound waves?

....[1]

(b) On Fig. 7.1, mark on the axis PY

(i) one point C where there is a compression in the wave, [1]

(ii) one point R where there is a rarefaction in the wave. [1]

(c) Describe the motion of a group of air particles situated on the path of the wave shown in Fig. 7.1.

....

....

....[2]

(d) The sound wave shown has speed of 340 m/s and a frequency of 200 Hz.
Calculate the distance represented by PX on Fig. 7.1.

distance = ...[2]

Topic 9 – Sound waves (Mark scheme)

1

(c)	no sound heard / quieter sound	B1
	medium/air required to transmit sound **OR** sound does not travel through a vacuum	B1

2

(a)		speed of sound in gas: 300 m / s	B1
		speed of sound in solid: 3000 m / s	B1
(b)		particles / molecules / atoms oscillate / vibrate OR pressure variation / compressions / rarefactions / displacements <u>move</u>	B1
		in the direction of travel (of the wave / sound)	B1
(c)	(i)	two complete wavelengths / cycles with shorter wavelength	B1
		wave drawn has greater amplitude	B1
	(ii)	higher frequency / pitch	B1
		louder / higher volume	B1
			[Total: 8]

3

(a)	light in air	BOX 5	3×10^8 m / s	B1	
	sound in air	BOX 2	300 m / s	B1	
	sound in water	BOX 3	1500 m / s	B1	[3]

(b)	distance = speed × time in any form NOT speed = $2d/t$	C1	
	t_{air} = 120 ÷ value for speed of sound in air	C1	
	t_{rail} (= 120 / 5000) = 0.024 s	C1	
	(time difference =) candidate's t_{air} – candidate's t_{rail} correctly evaluated (expect 0.400 – 0.024 = 0.376 s)	A1	[4]
			[Total: 7]

4

(a) 15–25 Hz to 15 000–25 000 Hz / 15–25 kHz B1

(b) **(i)** (region) where air layers/molecules/particles are pushed together/moved together/ closer (than normal)
OR (region) where (air) pressure raised/air (more) compressed/more dense B1

(ii) (region) where air layers/molecules are pushed apart/far(ther) apart (than normal)
OR (region) where (air) pressure reduced/air expanded B1

(c) **(i)** (sound is) loud(er) OR volume (of sound is) increased B1

(ii) sound has a higher frequency/pitch OR higher note (heard) B1

(d) 3.5 – 1.9 OR 1.6 (s) seen OR $v = 2d/1.9$ C1
250 × 2 OR 500 (m) seen OR $v = (2d + 500)/3.5$ C1
(speed = 500 / 1.6 =) 312.5 m/s at least 2 sig. figs A1

[Total 8]

5

(a) **(i)** **1.** compressions and/or rarefactions closer together
OR more compressions and/or rarefactions B1
ignore wavelength shorter

2. layers closer together at compressions B1
layers farther apart at rarefactions B1
OR
compressions narrower (B1)
rarefactions wider (B1)
ignore wavelength shorter ignore 'amplitude greater' ignore 'maximum displacement greater'

(ii) distance between 2 compressions or 2 rarefactions shown with reasonable accuracy B1

(b) time taken by sound in air = 200 / 343 = 0.583 s C1
time taken by sound in steel = 0.583 – 0.544 = 0.039 s C1
5128 m/s A1 [7]

6

(a) **(i)**	320-350 m/s condone 100 – 999 m/s	B1	
(ii)	3×10^8 m/s condone $2 - 4 \times 10^8$ m/s	B1	[2]
(b)	<u>use of</u> $v = f\lambda$	C1	
	correct evaluation of candidate's **(a)(i)**/1.2 (330 m/s gives 275 Hz)	A1	[2]
(c) **(i)**	correct evaluation of candidate's **(a)(i)** × 4.8 (330 m/s gives 1584m)	B1	
(ii)	<u>clear</u> statement that light travels instantaneously o.w.t.t.e. OR distance of thunderstorm same as distance travelled by sound OR thunder and lightning caused by same event OR negligible wind	B1	[2]

7

(a)	compression	B1	
	rarefaction	B1	[2]
(b)	cone moves forward / in direction of travel of wave OR cone pushes air particles closer o.w.t.t.e.	B1	
	cone moves backwards / away from direction of travel of wave OR cone causes empty spaces o.w.t.t.e.	B1	[2]
(c) **(i)**	loudness increases AND pitch same	B1	
(ii)	loudness same AND pitch increases	B1	[2]

8

(a) idea of light travelling (much) faster than sound B1

(b) **(i)** 4.0 (min) B1

(ii) always a (measurable) time difference / never zero time difference
Ignore time would be less B1

(iii) distance/time in any form, symbols, words, numbers OR 1200/3.6 C1
333.3 m/s to 2 or more sig figs A1

(iv) idea of light travelling instantaneously OR no wind
OR idea of lightning at ground level OR no obstruction to sound
Ignore echoes B1

(c)

	light waves	sound waves
longitudinal		✓
transverse	✓	
electromagnetic	✓	
mechanical		✓

–1 e.e.o.o. i.e. 1 mark subtracted from <u>3</u> for each error or omission B3 [9]

9

(a) **(i)** approximately 330 m/s
(correct order of magnitude) B1

(ii) 300 / 5000 OR t = d/v NOT t = 2d/v C1
0.06 s A1

(b) sound through air <u>and</u> sound through steel NOT echo B1

speeds in air and steel are different NOT if faster in air
accept sound in steel/rail heard first <u>B1</u> [5]

10

(a) **(i)** diagram showing compressions and rarefactions
(could be either spaced vertical lines or dots, or coil or sine wave) B1
2C's and 2R's in approx correct place B1

(ii) wavelength correctly marked, by eye B1

(b) **(i)** all 3 in correct positions B1

(ii) radio (waves) B1

(iii) 3×10^8 m/s B1

[Total: 6]

11

(a)	source of sound (e.g. gun/hooter), tape (100 m), stopwatch NOT clock, metre rule (unless lab method)	B1	[1]
(b)	distance and time between "flash and bang" (must be clear)	B1	[1]
(c)	distance/time OR d/t OR 2d/t	B1	[1]
(d)	further apart/more accurate timer/repeat/any other	B1	[1]
(e)	speed of sound in air, tick 100	B1	
	speed of sound in water, tick 1000	B1	[2]
			[Total: 6]

12

(a)	Longitudinal or pressure waves	B1	**1**
(b)	a correct C marked	B1	
	a correct R marked	B1	**2**
(c)	oscillation/vibration/backwards and forwards	M1	
	along PY (consider pressure waves as alternative)	A1	**2**
(d)	wavelength = 340/200	C1	
	PX(= λ/2) = 0.85 m	A1	**2**
			[7]