OCR GCSE GATEWAY PHYSICS A · J249

PHYSICS



MARK SCHEME

P5.1 WAVE BEHAVIOUR

SCORE	PERCENTAGE
/150	%

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Question			Answer/Indicative content	Marks	Guidance
1	a	i	B [1]	1	more than one scores 0 marks if answer line blank allow correct answer indicated in list or on diagram **Examiner's Comments** Nearly all could identify a compression on a longitudinal wave.
		ii	wavelength [1]	1	**Examiner's Comments** Recognising the distance between the same point on consecutive waves as wavelength discriminated very well. This proved to be far more challenging than when presented as the distance between two consecutive compressions.
	b		no (no mark) (idea that) we can't hear high pitched sounds [1] **BUT** We cannot hear 20 000 (Hz) (or above) scores [2]	2	'yes' scores [0] **allow** (idea that) 25 000 (Hz) is higher than we can hear [1] **allow** frequencies above a threshold: eg. Can't hear above 18 000 (Hz) [1] **allow** 20kHz **allow** correct references to wavelength for [1] **Examiner's Comments** On this 2 mark question most candidates stated that the ultrasound could not be heard as the frequency or pitch was too high [1]. Better answers qualified that by adding the upper threshold of 20 000Hz [1].
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
2	a	i	ideas of: (**for test group**) inaccurate or unreliable measurement(s) [1] (**for test group**) small(er) sample in group / [1] (**for test group**) group not representative / research more representative [1]	3	 Eg. Equipment may be faulty [1] Eg. method may be flawed [1] Eg. large(r) sample in research [1] **allow** example of how the group is not representative Eg. **Test group**, some have a hearing impairment [1] Eg. All aged16 in test group / AW [1] Eg. (**test group**) result(s) look anomalous [1] Examiner's Comments Few scored all three marks and the majority only one mark, usually referring to the age. Rather fewer mentioned the small test sample.
		ii	19 000 [2] **but if answer is incorrect or incomplete then:** evidence of multiplying average by 5 [1] **or** $\frac{80\,000 + \text{Dionne}}{5}$ [1]	2	**If no answer on answer line check table** Examiner's Comments Most calculated the average correctly as 19000Hz [2]. Although some treated the average as an included person and quite a few used the wrong column.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	**any 2 from:** greater hearing loss with ageing [1] greater hearing loss with greater frequency [1] rate of hearing loss increases with ageing [1] rate of hearing loss increases with increasing frequency [1]	2	**Eg.** as you get older your ability to hear reduces [1] **BUT allow** as you get older your ability to hear higher frequencies reduces [2] Examiner's Comments Most scored one mark with better candidates scoring the second for correct reference to the frequency. Some didn't spot the frequency loss and there were communication problem with some candidates describing the graph.
		ii	hearing aid lowers (6000Hz) sounds to 3000(Hz) [1] (with hearing aid) less hearing loss at 3000(Hz) / lower frequency sounds heard more easily [1] (at age 60) hearing aid reduces hearing loss by 10 – 15(dB) / AW [1]	3	**Look for use of data in answers.** **Allow** other value of frequency correctly halved [1] **ignore** just frequency halved **Eg.** better hearing (range) at 3000(Hz) **Eg.** (at 60) aid reduces hearing loss from 27 to 13 (dB) **Allows** halves hearing loss [1] Examiner's Comments There were problems with candidates communicating their ideas. Few answered it fully, using data on frequency, hearing loss and applying this to the function of a hearing aid.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
3			Level 3: (5 – 6 marks) Answer shows understanding of For higher frequencies the speed slows / direction changes the most. AND for higher refractive index the speed slows / direction changes the most. Quality of written communication does not impede communication of the science at this level. Level 2: (3 – 4 marks) Answer shows understanding of the nature of the colour of light. Quality of written communication partly impedes communication of the science at this level. Level 1: (1 – 2 marks) Answer shows a simple appreciation of the nature of light. Quality of written communication impedes communication of the science at this level. Level 0: (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted up to grade A* NB. Answers can be given (ORA) in terms of red light. Indicative scientific points may include: Level 3: • violet light has highest frequency / shortest wavelength and speed slows most / direction changes the most / AW • violet light has highest refractive index and slows most / direction changes the most / AW Level 2: • EITHER violet light slows down most • OR violet light has higher frequency / shorter wavelength • OR violet light has higher refractive index Level 1: • EITHER light slows down when entering glass • OR different colours have different speed changes • OR different colours have different refractive index • OR different colours have different frequencies / wavelength Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments?? This six-mark level of response question on dispersion was intentionally challenging assessing over a grade range up to A*. It discriminated well. There were very few good complete answers with references to refractive index usually omitted. There were many good answers that scored five marks in term of frequency or wavelength. Common misconceptions in this question were to do with the misuse of scientific

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Question			Answer/Indicative content	Marks	Guidance
					words. Diffraction and reflection were frequently interchangeable with refraction. Also many got the wavelengths and colours mixed up although these often gained level one marks for the idea than different colours have different frequencies.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
4			[Level 3] descriptions about all three from: –ultrasound v surgery –ultrasound v X rays –detailed information about the display Quality of written communication does not impede communication of the science at this level (5 – 6 marks) [Level 2] descriptions about any two from: –ultrasound v surgery –ultrasound v X rays –basic information about the display Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) [Level 1] descriptions about any one from: –ultrasound v surgery –ultrasound v X rays –basic information about the display Quality of written communication impedes communication of the science at this level (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A*. ultrasound used rather than surgery may include: non-invasive / no damage to human / no scars (more) accurate method fat thickness can be measure at different parts of the body quick method ultrasound used rather than X rays may include: produces images / readings / results for soft tissue does not damage living cells **allow** reverse arguments e.g. x rays do not show soft tissue detailed information about the display may include: peak **A** is at 5 – 7 (mm) peak **A** is at the fat-muscle layer the thickness of fat in the arm is 5 – 7 (mm) peaks **A B** and **C** are at different depths in the body basic information about the display may include: each peak is at a tissue boundary waves reflect from tissue **boundary** the first peak shows the body fat thickness (shows) reflections at different depths / distances Use the L1, L2, L3 annotations in scoris. Do not use ticks. <u>Examiner's Comments</u> This was a six-mark level of response question to do with ultrasound scans. It was targeted at a range of grades up to A* and it discriminated well showing the full range of marks. The question asked candidates to compare its use for

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Question			Answer/Indicative content	Marks	Guidance
					measuring body fat with using surgery or X-rays. There was also an ultrasound graph to prompt answers. The three areas for marking were discussing ultrasound versus X-rays, ultrasound versus surgery and the display itself. Many answers failed to mention surgery at all and a significant number did not refer clearly enough (or at all) to the graph and what it showed. Ultrasound versus X-rays was well covered by most with references to its inability to detect soft tissues or its ability to ionise cells or increase the risk of cancer. Regarding the display weaker candidates thought that each peak was a fat layer. Surgery as hinted at already was often omitted when a simple statement such as it can cause scars or a greater risk of infection would have got many answers a higher level of marks.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
5	a	i	elephant (1)	1	**Examiner's Comments** Almost all selected the correct animal.
		ii	dolphin (1)	1	**Examiner's Comments** Almost all selected the correct animal.
		iii	dolphin (1)	1	**Examiner's Comments** Almost all selected the correct animal.
	b	i	Dionne (1) 20 100 – 24 (is largest value) **OR** 20 076 (is largest value) (1)	2	The calculated value may be shown in the table **If** Dionne is **calculated** to be less than 19985 (Evangelos) then award one mark for naming Evangelos. **Examiner's Comments** Almost all scored at least one mark and many scored two for selection of the person with the largest range, frequently supported by appropriate calculation.
		ii	19 780 scores (2) **but if answer is incorrect or incomplete then:** $\frac{19\,000 + 20\,000 + 20\,100 + 19\,800 + 20\,000}{5}$ (1)	2	**Mark answer on line** **But** if no answer given and value calculated in table mark the answer calculated in the table. **Examiner's Comments** Most scored at least one mark for the attempt to calculate the mean from the data. Almost all higher ability candidates scored two marks. The most frequent reason for not scoring the full two marks was incorrect completion of the final calculation of the mean.

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Question			Answer/Indicative content	Marks	Guidance
		iii	Any three from inaccurate measurements (1) unreliable measurements (1) idea of different sample size (1) the sample is not representative (1) some (may) have a hearing defect (1) different ages in the sample (1) other named and described reason why the sample is unrepresentative (1)	3	Eg. Equipment may be faulty [1] **Examiner's Comments** This was less well-answered across the full range. Most frequently candidates recognised that disability and age were the most significant reasons for inconsistency in the data. Very few candidates made reference to the very small sample size or inaccuracy in making measurements.
			Total	**10**	
6			(… it) **REFRACTS** (and _ _ _ _ _ _ _). (1) (… colour A is) **RED**. (1) (… has the shortest) **WAVELENGTH**. (1)	3	**not** reflects Examiner's Comments ??Most scored [2] usually for knowing the order of the spectrum produced by the dispersion through a prism.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
7		i	speed = 0.96 (m/s) [2] **but if answer is incomplete then** 0.80 × 1.2 [1]	2	**allow** correct substitution of a reasonable wavelength **only acceptable alternatives allowed are:** 1.92 [1] (i.e. 1.60 × 1.2) [1] 0.48 [1] (i.e. 0.4 × 1.2) [1] **but** ignore other wavelengths when awarding this mark Examiner's Comments This question was about p and s waves and it was better answered than equivalent questions in the past. In part (i) a few used the correct wavelength (0.8m) to calculate the speed [2]. Rather more used two wavelengths (1.6m) to calculate the speed as 1.92 [1]. This distinction discriminated well.
		ii	0.11(m) [1]	1	if not answer on line allow correct answer indicated in list Examiner's Comments This question was about p and s waves and it was better answered than equivalent questions in the past. In part (ii) a popular incorrect response for the amplitude was 0.22 although about 40% halved this value correctly [1] in their answers.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
8	a		Maximum 2 marks **B** (Front row music festival) **C** (Large orchestra) **D** (Aircraft at take-off) **H** (MP3 player at maximum volume)	2	Mark letters on the line first If nothing on the line accept circled or ticked or underlined letters All 4 correct (with none wrong) [2] **BUT** 3 or 4 correct with one wrong [1] No mark awarded if 2 incorrect **Examiner's Comments** Almost all selected the 4 loudest sounds.
	b	i	Loudness reduces with (increasing) distance [1] **BUT** (idea that) loudness falls quickly (with increasing distance) at first and slower later [2]	2	**allow** higher level answers **allow** it changes very little after 22 to 24 metres [1] **Examiner's Comments** Most scored [1] mark for loudness decreasing with distance from source. Very fewgained [2] for interpreting the decreasing gradient as the rate of decrease dropping with increasing distance.
		ii	82 to 83 (dB) [1]	1	**Examiner's Comments** Most used the graph correctly to find the loudness. When mistakes were made it was usually due to incorrectly reading from the loudness axis rather than incorrect construction of lines on the graph

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Question			Answer/Indicative content	Marks	Guidance
		iii	**any two from** Gardener above safe level / 90dB AW [1] People in house under safe level /90dB AW [1] (idea that) gardener is exposed to the noise for more time [1]	2	 **allow** (idea that) gardener is very close (so it is much louder) [1] **allow** (idea that) sound is stopped by walls or windows [1] **Examiner's Comments** Almost all scored at least [1] and many scored [2] for loudness being too high very close by or that the walls or windows blocked sounds
	c	i	4 (hours) [1]	1	**allow** 3 – 6 (hours) **Examiner's Comments** Almost all interpolated correctly within the allowed range
		ii	Less than (4 minutes) [1]	1	**NOT** less than or equal to 4 minutes **allow** up to 4 minutes [1] **Examiner's Comments** Most recognised the mathematical symbol correctly. Often the mark was not gained due to describing it as “4 minutes or less”.
		iii	Any value from 78 to 79 (dB) [1]	1	 **Examiner's Comments** This discriminated well with very few candidates able to process the data (showing exponential decay in exposure time with loudness) to calculate loudness.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
9			2.2×10^{14} Hz (3) **if incorrect or incomplete then allow:** 2.22×10^{14}Hz **or** 2.222×10^{14}Hz (2) **or** 2.0×10^{14} or 2.2 or 2.22..etc (1) **or** (for correct substitution) $f = \frac{2 \times 10^{8}}{9 \times 10^{-7}}$ (1)	3	**Allow** any other value that rounds to 2.2×10^{14} (2) Allow 2.2×10^{x} or $2.22\ldots \times 10^{x}$ (1)
			Total	3	
10		i	**C** (1)	1	if answer line blank allow answer in correct place on the diagram
		ii	**any one from** movement of air (particles) (1) can't see **air particles** (1) (frequency) too high (1)	1	**allow** the air particles are moving too fast (1) **ignore** cannot see the wave
			Total	2	
11			15.0 (m / s) (1)	1	**Allow** 15
			Total	1	
12			**C** ✓	1 (AO1.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
13			B ✓	1 (AO2.2)	Examiner's Comments Candidates found this question challenging and many candidates selected distractor A as their answer. Key Misconception Candidates knew that the ray should enter and leave the block in the same direction (options A and B). However, the ray is also refracted as it enters the glass block and this is independent of the angle of incidence. Therefore option B is the only correct answer.
			Total	1	

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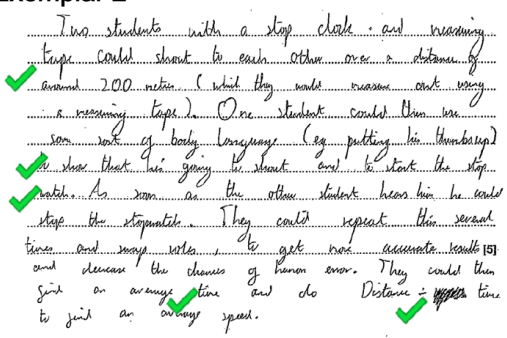
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Question			Answer/Indicative content	Marks	Guidance
14	a	i	2 ½ or 2.5 ✓	1 (AO1.2)	<u>Examiner's Comments</u> Most candidates were able to calculate the number of waves produced. The most common error made was to divide the time by the frequency instead of multiplying the time by the frequency.
		ii	**Speed** is unchanged / stays the same ✓ **Wavelength** reduces ✓	2 (AO2.1) (AO2.1)	Answer **must** indicate idea of speed Answer **must** indicate idea of wavelength **IGNORE** answers that merely state 'no change and reduces' <u>Examiner's Comments</u> Most candidates correctly stated that the wavelength would decrease. The majority of candidates stating that wave speed would also increase while only the highest ability candidates knew that that wave speed would be unchanged.
		iii	Any two from: Water / particles move up and down / oscillate vertically ✓ Water / particles move at 90° / perpendicular to the direction of wave (travel) / AW ✓ Energy moves in direction of the wave (travel) / AW ✓	2 (AO2 × 2.1)	**IGNORE** any statements that are just repeated from the question. **IGNORE** water waves move up and down **ALLOW** energy moves at 90° to wave vibrations / movement ✓✓ <u>Examiner's Comments</u> Candidates found this question very challenging and many misinterpreted what they were being asked to do. Most candidates did not identify that the second and third statements about water wave were incorrect and many merely rewrote the student's original statement. The most common mark gained was for the idea of the water moving perpendicular to the direction of the wave motion. Only the highest ability candidates gained full credit.

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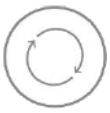
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Question			Answer/Indicative content	Marks	Guidance
	b		(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat **and** average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	**5** (AO1.1) (AO2.2) (AO2.2) (AO3.2b) (AO3.3b)	**ALLOW** marks to be awarded from a clear diagram **ALLOW** higher level methods eg using standing waves **ALLOW** equation in any form Examiner's Comments This question assessed AO1, AO2 and AO3 and discriminated well between the lower and higher ability candidates. Many correct experiments were suggested, for example practical improvements to the ball being hit by a bat making use of echoes, microphones and oscilloscope, as well as less practical suggestions in a school setting involving the use of fireworks and explosions. Some candidates made vague references to 'using a computer' that could not be credited. Most candidates realised that it was necessary to measure a time, but did not clearly specify what time they should measure. Almost every candidate gained some credit, many for stating the correct equation to calculate speed or for the idea of taking multiple readings and then using the average value. **Exemplar 2** 

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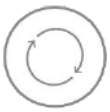
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Question			Answer/Indicative content	Marks	Guidance
					This candidate gained full credit. The response included: • a suitable experiment • an appropriate time and distance measured • an equation to calculate the speed • the improvement of repeating and averaging the readings in order to improve accuracy and reduce the effect of operator error on their observations.
	c		**Any 3 from:** Outer ear (pinna) / auditory canal transfers sound to ear drum ✓ Ear drum vibrates ✓ Ossicles / small bones / anvil, hammer or stirrup vibrate ✓ Ossicles / small bones / anvil, hammer or stirrup amplify vibration ✓ Liquid in cochlea transmits movement (to small hairs) ✓ Small hairs / cilia vibrate ✓	3 (AO1.1) (AO2 × 2.1)	**ALLOW** ear drum moves in and out <u>Examiner's Comments</u> Most candidates gained at least 1 mark for either the eardrum, ossicles or cilia vibrating. Good responses were able to mention all 3 of these vibrations. Candidates who achieved zero or 1 mark, did not use the word 'vibrate', merely listing the parts of the ear that the sound travelled through.
			Total	13	
15			**B** ✓	1 (AO 1.1)	<u>Examiner's Comments</u> This question was generally answered well. Some candidate incorrectly selected either A the normal or C.  **AfL** With ray diagrams, candidates should always identify the normal, before working out further positions of the rays.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
16			C ✓	1 (AO 1.2)	Examiner's Comments This question was answered correctly by most candidates and many had added a column to the table to determine the range for each of the four distances.
			Total	1	
17			B ✓	1 (AO 2.2)	Examiner's Comments Candidates found this question very challenging and the most common response was distractor A.  AfL A better way for candidates to approach this question would be to consider refraction occurring with a change of speed and the effect across a wavefront. In diagram A, a change of speed would change the speed of all parts of the wavefront by the same amount so that the wavefront would continue to move 'in step'. Response B is the correct answer since it would not be possible to have an angle of refraction of 0° with an angle of incidence greater than 0°. Similarly, for the emergent ray it would not be possible to have an angle of refraction greater than 0° if the angle of incidence is 0°.
			Total	1	

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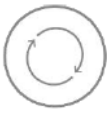
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Question			Answer/Indicative content	Marks	Guidance
18	a	i	3.5 (cm) ✓	1 (AO 1.1)	ALLOW 3.4 to 3.6 Examiner's Comments One in five candidates answered this question correctly. Some candidate confused wavelength with the amplitude. Another common response was 9 cm.
		ii	2.4 (cm) ✓	1 (AO 1.1)	Examiner's Comments Many candidates read the vertical axis incorrectly and gave values that were around 2.4 cm but not that specific value (for example 2.5 cm).  Misconception A common incorrect answer was 4.8 cm, where candidates confused the peak to peak value with amplitude. Other candidates confused amplitude with the wavelength.

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Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s) award 2 marks 2 × 25 OR 2 × 0.25✓ 0.5 (m/s) ✓	2 (AO 2 x 2.1)	ALLOW 50 Examiner's Comments Most candidates were credited with one mark for multiplying 2 by 25 to give an answer of 50. Fewer candidates appreciated that this was 50 cm/s while the unit on the answer line was m/s.  AfL Encourage candidates to check the unit used on the answer line. This additional information can help them to understand the question and the equations they should use.
	b	i	(Particles move) up and down / oscillate/vibrate vertically/at right angles to the direction of the wave ✓	1 (AO 1.1)	

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Question			Answer/Indicative content	Marks	Guidance
		ii	(Particles move) forwards and backwards / oscillate/vibrate parallel to the direction of the wave / AW ✓	1 (AO 1.1)	Examiner's Comments Very few candidates were able to express a clear understanding of the motion of particles caused by the progress of a transverse water wave, or a longitudinal sound wave. A number of candidates stated used ambiguous descriptions such as 'the particles would move side to side', which could apply to both transverse and longitudinal waves.  OCR support The Waves in Matter transition guide (from KS3 to KS4) provides guidance on the teaching about waves. http://www.ocr.org.uk/Images/318139-waves-in-matter-transition-guide.pdf
			Total	6	

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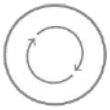
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Question			Answer/Indicative content	Marks	Guidance
19	a		Distance (between source and observer) ✓ Time (for sound to travel between source and observer) ✓	2 (AO 2 x 1.1)	Do not accept distance / time the ball travels Do not accept metres / seconds Examiner's Comments Some candidates wrote a list of quantities that could be measured with no description: speed, distance, time, frequency and wavelength. These candidates could not be credited with any marks as they had not answered the question. Candidates were expected to describe how the distance that the sound would travel and the time for the sound to travel were needed to calculate the speed. Many candidates ignored the context for the question and referred to measuring the distance the ball travels.
	b		Speed = distance ÷ time ✓	1 (AO 1.1)	ALLOW distance ÷ time Examiner's Comments This question was answered well by candidates. Some candidates quoted the wave equation which was not appropriate to the experiment. A significant number of candidates incorrectly gave the correct equation as *speed = distance × time*..
	c		Takes several readings / take averages / increase distance ✓	1 (AO 3.3a)	ALLOW no wind IGNORE increase time Examiner's Comments Most candidates suggesting repeating the experiment and calculating an average. Some candidates suggested using different distances and then plotting a graph. Other candidates suggested increasing the distance to the observer.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
20			Thinking distance doubles ✓	1 (AO1.1)	ALLOW higher level answer: thinking distance is (directly) proportional to speed Examiner's Comments Around half the candidates stated that thinking distance also doubled and used data from the table to demonstrate their answer. Many of the candidates who did not gain credit stated that the thinking distance increases but without using the information from the question of the speed doubling. Other candidates did not answer the question set but explained factors that could affect thinking distance. A few candidates referred to the 'thinking time' doubling.  AfL When investigating stopping distances, candidates should be encouraged to understand fully the terms thinking distance, braking distance, thinking time, braking time. Encourage candidates to underline the important parts of the question – in this case thinking distance (which was already emboldened) and speed doubles.
			Total	1	

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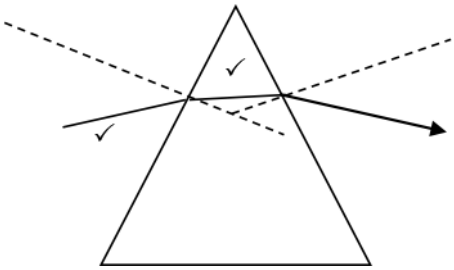
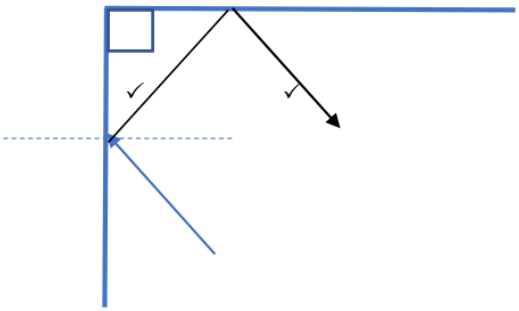
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Question			Answer/Indicative content	Marks	Guidance
21			D ✓	1 (AO 2.2)	Examiner's Comments This question assessed candidates' knowledge of refraction of sound waves. Around a third of candidates did not know that a sound wave travels faster in water than air.  Misconception Many candidates had the misconception that a sound wave slows down when it enters water and incorrectly chose option B.
			Total	1	
22			A ✓	1 (AO 1.2)	Examiner's Comments Most candidates successfully applied their knowledge of electromagnetic waves to identify that the energy transfer for row A was correct.
			Total	1	
23			B ✓	1 (AO 1.1)	
			Total	1	

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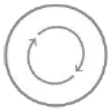
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Question			Answer/Indicative content	Marks	Guidance
24	a		Diagram showing correct refractions 	2 (AO 2x1.2)	If diagram is incorrect, maximum of one mark from: any rising line in air before the prism ✓ a line in the prism close to horizontal by eye and joining the exit ray ✓ IGNORE any arrows on rays <u>Examiner's Comments</u> This question proved very difficult for most candidates. Although some candidates could accurately draw the ray of light as it travelled through the glass prism, only the more able gained 2 marks.
	b			2 (AO 2×1.2)	One mark for each correct reflection of about 90o by eye IGNORE any arrows on rays
			Total	4	

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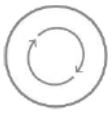
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Question			Answer/Indicative content	Marks	Guidance
25	a	i	Mean = (0.28 + 0.32) = 0.30 (s) ✓	1 (AO 1.2)	**ALLOW** 0.3 (s) **DO NOT ALLOW** answers with all 3 readings used giving a mean of (0.28+0.32+0.54) / 3 = 0.38 (s) Examiner's Comments  **AfL** Candidates need to be aware that anomalous readings in a set of results, due to a mistake or lack of attention, are not included in calculations of the mean.

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Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 333 (m/s) award 4 marks Use of distance = 100 m ✓ Recall (s =) d / t ✓ 100 / 0.3 ✓ (s =) 333 (m/s) (3 sig. figs.)✓	4 (AO 2.1) (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from 24(a)(i) ALLOW 100 ÷ 0.38 ✓✓✓ ALLOW 263 (m/s) ✓✓✓✓ ALLOW ECF for 3rd and 4th marking points if incorrect distance is used ALLOW 50 ÷ 0.3 or 166.7 ✓✓ ALLOW 50 ÷ 0.38 or 131.6 ✓✓ ALLOW 132 ✓✓✓ ALLOW 167 ✓✓✓ Examiner's Comments The majority of candidates could rearrange the equation provided, substitute values and give their answer to 3 significant figures. However, many candidates did not take into account that the sound travelled 100m to the wall and back again so used 50m in their calculations instead.  AfL A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct.

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Question			Answer/Indicative content	Marks	Guidance
		iii	**Any two from:** Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2 (AO 2×3.3b)	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings. Examiner's Comments This Assessment Objective 3 question required candidates to analyse information in order to develop the experimental procedure of the students (in Question 24(a)). There is evidence that over half of the candidates did not read the question carefully as they suggested improvements relating to other methods such as videoing, using microphones etc. Many candidates suggested taking more readings but did not mention calculating the mean and therefore could not score the mark.
	b		idea of 3 echoes/reflections/returning pulses (from each pulse) / AW✓ takes different times to travel (there and back) through different layers/distances/thicknesses / time (interval) between echoes is different/not regular / AW ✓✓ **BUT** the thicker the layer/the longer the distance, the bigger the time interval/takes longer to travel (there and back) / AW ✓✓	3 (AO 3×2.1)	**ALLOW** (idea of measuring) the time taken for the wave to be reflected back (for different layers) Examiner's Comments This question assessed candidates' ability to apply their knowledge of ultrasound. It proved challenging to a number of candidates and about one third did not gain any credit. Candidates used their knowledge of ultrasound but often did not relate this to the question asked, or their answers were not specific enough e.g. the number of pulses shows that there are 3 layers of tissue.
			Total	**10**	
26			**D** ✓	1 (AO1.2)	Examiner's Comments The majority of candidates correctly identified that a ruler and a stopwatch should be used to measure the speed of water waves. A common incorrect response was an ammeter and stopwatch.
			Total	**1**	

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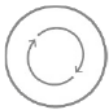
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Question			Answer/Indicative content	Marks	Guidance
27			C ✓	1 (AO1.1)	Examiner's Comments This question was also based on the electromagnetic spectrum section of the specification. Candidates had a better understanding of the main groupings of the electromagnetic spectrum from long to short wavelengths and from low to high frequencies. An alternative way of answering this question is to apply the wave equation realising that the speed of electromagnetic waves in a vacuum is constant.
			Total	1	
28			D ✓	1 (AO2.2)	Examiner's Comments This question proved very challenging. Many candidates incorrectly gave the answer as B without realising that the question referred to a sound wave. Candidates needed to know that sound travelled faster in water than in air.
			Total	1	
29			A ✓	1 (AO1.1)	Examiner's Comments This question required candidates to read the options carefully. Many candidates did not realise the direction was important.
			Total	1	

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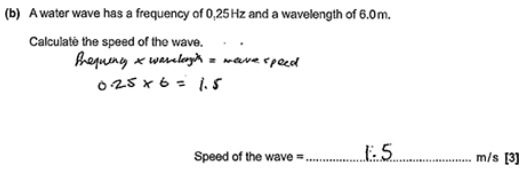
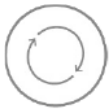
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Question			Answer/Indicative content	Marks	Guidance
30	a	i	2 (s) ✓	1 (AO1.2)	Examiner's Comments A small proportion of candidates gained this mark for a period of 2 s. The majority of candidates wrote 12 s being the total time shown. A few candidates wrote 1 s.
		ii	3 (cm) ✓	1 (AO1.2)	Examiner's Comments Over half the candidates scored the mark for 3 cm. The common incorrect answer was 6 cm (peak to trough).
		iii	the number of (complete) waves / oscillations in a / per second ✓	1 (AO1.1)	ALLOW '2 waves in a second' ✓ Examiner's Comments Candidates often did not refer to a time of one second. The word "amount" was often used instead of "number". Many vague responses such as "how many times something happens" or "how fast something is" were seen. Candidates are expected to define frequency (and wavelength).  AfL Candidates should be able to know and apply basic wave terms such as amplitude, wavelength, frequency and period.

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Question			Answer/Indicative content	Marks	Guidance
	b		FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 1.5 (m/s) award 3 marks** Wave speed = frequency × wavelength / v = f × λ ✓ = 0.25 × 6 ✓ 1.5 (m/s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	<u>Examiner's Comments</u> Candidates needed to recall the wave equation and substitute the numbers. Many candidates gained the marks on this question. Candidates who did not do well on this question often did not write an equation in their answer. **Exemplar 2**  (b) A water wave has a frequency of 0,25 Hz and a wavelength of 6,0 m. Calculate the speed of the wave. frequency × wavelength = wave speed 0.25 × 6 = 1.5 Speed of the wave = 1.5 m/s [3] This candidate has stated the equation with the wave speed as the subject. The candidate has then substituted the numbers before calculating the answer.  **AfL** For calculations, candidates should show their working. The following steps are useful: 1. Recall equation (if not given in the question) 2. Rearrange equation 3. Substitute the numbers into the equation 4. Calculate the answer 5. Consider significant figures or decimal places
	c	i	(transverse) Wave movement shown  ✓	1 (AO2.2)	<u>Examiner's Comments</u> This question required candidates to demonstrate their understanding of the differences between transverse and longitudinal waves. Many candidates drew arrows pointing left to right towards the barrier

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Question			Answer/Indicative content	Marks	Guidance
		ii	Reflection at wall ✓	1 (AO1.2)	**ALLOW** bounces back / comes back towards the hand Examiner's Comments It was expected that candidates would state that the wave would be reflected. Candidates should be encouraged to use technical terms such as "reflect" rather than "bounce". Many candidates stated that the wave would stop at the wall.
		iii	The coils / slinky /spring are in the same place (as before the wave) / AW ✓	1 (AO1.1)	The coils do not travel from one end to the other Must have reference to coils / slinky / spring Examiner's Comments This was a challenging question. Many candidates answered it by describing water waves rather than referring to the slinky spring model. To gain credit candidates needed to explain that the coils remain in the same positions.
			Total	9	
31			C ✓	1 (AO2.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
32	a	i	Transverse ✓	1 (AO1.1)	
		ii	Molecules/Particles move perpendicular/ right angles (to the direction of energy transfer/water surface) ✓	1 (AO1.1)	ACCEPT at right angles/ 90° (to direction of travel) ACCEPT up and down1
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (Hz) award 2 marks Frequency = number of waves per second / = 10 ÷ 20 ✓ *f* = 0.5 (Hz) ✓	2 (AO2 × 2.1)	ACCEPT ½
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.06 (m / s) award 3 marks Speed = 0.6 × 0.1 ✓ Speed = 0.06 (m / s) ✓	2 (AO2 × 2.1)	
		ii	Distance is measured with a metre-rule OR tape measure ✓ Time is measured with a stop-watch ✓	2 (AO2 × 1.2)	ACCEPT metre-ruler DO NOT ALLOW ruler
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.08 (m / s) award 3 marks Speed = distance ÷ time ✓ = 2.4 ÷ 30 ✓ = 0.08 (m / s) ✓	3 (AO1 × 1.2) (AO2 × 2.1)	
		iv	Uncertainty/difficulty in measuring distance ✓ OR Human reaction time in starting/stopping stopwatch ✓	1 (AO3.2a)	ALLOW AW
			Total	12	
33			A ✓	1 (AO1.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
34			A ✓	1 (AO2.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
35	a		Ultrasound waves are <u>longitudinal</u> ✓ **OR** Ripples are <u>transverse</u> ✓ Oscillations/vibrations (of particles) in ultrasound/longitudinal waves are <u>parallel</u> to the direction of energy transfer / ultrasound has compressions and rarefactions ✓ **OR** Oscillations/vibrations (of particles) in the ripples/transverse waves are <u>perpendicular</u> to the direction of energy transfer ✓	2 (AO2 × 1.1)	**ALLOW** direction of travel/propagation for energy transfer **IGNORE** direction of wave motion
	b	i	0.0022 (m) ✓	1 (AO2.2)	
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.0×10^6 (Hz) award 4 marks** (Rearrange: frequency =) speed / wavelength **OR** (f =) 4500 / 0.0022 ✓ (f =) 2 045 455 (Hz) ✓ (f =) 2 000 000 (Hz) ✓ (f =) 2.0×10^6 (Hz) ✓	4 (AO1.2) (AO2 x 2.1) (AO1.2)	**ALLOW** ecf from **(i)** **ALLOW** three marks for 2.0 MHz **ALLOW** a mark for their answer to 2 significant figures **ALLOW** a mark for their answer in standard form
	c		Decreases ✓ Stays the same ✓	2 (AO2 × 2.1)	
	d	i	(Partial) reflection/absorption at the front of the kidney ✓ (Partial) reflection at the back of the kidney ✓	2 (AO2 × 2.1)	Both of the marking points can be awarded by a suitably clear diagram (or additional drawings on the given diagram) **ALLOW** 1 mark maximum for just reflection/bounces back
		ii	Measure the <u>time</u> between reflections ✓ Use distance = ½ x speed x time (to find the size) ✓	2 (AO2 × 2.2)	**ALLOW** distance = speed x time and mention of time halve

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Question			Answer/Indicative content	Marks	Guidance
	e		There is no (known) risk associated with ultrasound / ultrasounds are safer than X-rays / X-rays pass through soft tissue (so would not detect the kidney) / X-rays are ionising (radiation) ✓	1 (AO1.1)	**ALLOW** X-rays used to detect bones/pass through kidney **ALLOW** ultrasound detects soft tissue/organs
			Total	14	