Mark scheme – Wave Behaviour (F)

Question			Answer/Indicative content	Marks	Guidance
1	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**	
2			**C** ✓	1 (AO2.2)	
			Total	**1**	
3	a		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.5 (m/s) award 3 marks** Wave speed = frequency × wavelength / v = f × λ ✓	3 (AO1.2) (AO2.1) (AO2.1)	**Examiner's Comments** 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

			= 0.25 × 6 ✓ 1.5 (m/s) ✓		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
	b	i	(transverse) Wave movement shown ⇕ ✓	1 (AO2.2)	**Examiner's Comments** 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
		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.
	c	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 <u>second</u> ✓	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.
			Total	**9**	
4			**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**	

5			**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**	
6			**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**	
7			**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**	
8			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	**1**	
9			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**	
10	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*..
			Total	**3**	
11			**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**	
12			**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**	
13	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.
		iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.5 (m/s) award 2 marks**	**2 (AO 2 x 2.1)**	

			2 × 25 OR 2 × 0.25✓ 0.5 (m/s) ✓		**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)**	
		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**	
14			**B** ✓	**1 (AO 1.1)**	**Examiner's Comments** 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**	