	Answers	Extra information	Mark	AO / Specification reference
01.1	transverse		1	AO1 AO2 4.6.1.1
01.2	any correct wavelength – e.g., horizontally from peak to peak/trough to trough	any point on a wave to the same point on the next wave in the horizontal direction	1	AO1 AO2 4.6.1.2
01.3	move hand up and down a small distance the amplitude is the distance from the middle to the top or to the bottom of a wave		1 1	AO1 AO2 4.6.1.2
02.1	amplitude = half the peak to trough height $= \frac{34}{2} = 17$ m		1 1	AO2 4.6.1.2
02.2	period = $\frac{1}{\text{frequency}}$, 14.8 s = $\frac{1}{\text{frequency}}$ frequency = $\frac{1}{14.8}$ s =0.068 Hz speed = frequency × wavelength speed = 0.068 × 342 = 23(.2) m/s		1 1 1 1	AO2 4.6.1.2
02.3	accept values between 1.0 and 2.5 cm/0.01 – 0.025 m		1	AO3 4.6.1.2

	Answers	Extra information	Mark	AO / Specification reference
02.4	comparison of speeds and amplitudes using ratios if wave speed and amplitude are proportional, then $\frac{\text{wave speed}}{\text{amplitude}}$ = constant for ocean wave: $\frac{23.2}{17}$ = 1.4 (1.38) for ripple tank: $\frac{0.5}{0.02}$ = 25 the ratios are different, so wave speed is not proportional to amplitude	one mark for method of deciding proportionality explicitly stated or implied one mark for calculations one mark for conclusion consistent with calculations	1 1 1	AO3
03.1	the surface of the water moves up and down at 90°/perpendicular/at right angles to the direction of motion of the wave which moves across the pond		1	AO1 4.6.1.1
03.2	the air particles move backwards and forwards in the same direction as the motion of the wave so at 90° to the direction of motion of the water surface/particles on surface		1 1	AO1.1 AO2 4.6.1.1
03.3	speed = frequency × wavelength	accept $v = f\lambda$ or correct rearrangements	1	AO1
03.4	340 = 400 × wavelength wavelength = $\frac{340}{400}$ = 0.85 m		1 1 1	AO2 4.6.1.2
04.1	C above a place where the coils are close together R above a place where the coils are far apart		1 1	AO1 AO2 4.6.1.1

	Answers	Extra information	Mark	AO / Specification reference
04.2	distance of 1.5 m is for 3 waves because the wavelength is the distance from one compression to the next $\frac{1.5}{3} = 0.5$ m		1 1	AO1 AO2 4.6.1.1 4.6.1.2
04.3	speed = frequency × wavelength	accept v = fλ or correct rearrangements	1	AO1
04.4	1.0 = frequency × 0.5 frequency = $\frac{1.0}{0.5}$ = 2 Hz the person needs to move their hand in and out 2 times every second		1 1 1 1 1	AO2 4.6.1.1 4.6.1.2
05.1	sound waves		1	AO1 4.6.1.1
05.2	**Level 3**: Describes how to set up an experiment, with clear details about what would be seen, and what it shows. Answer shows clear organisation.		5-6	AO1 AO2 4.6.1.1 4.6.1.2 4.6.1.3
	Level 2: Describes the observations or an experiment with some details of what is seen or what it shows. Answer shows some organisation.		3-4	
	Level 1: Describes experiments or observations with limited detail. Answer shows poor organisation.		1-2	
	No relevant content.		0	

	Answers	Extra information	Mark	AO / Specification reference
	Indicative content: • you can show that water waves do not transfer water by putting a floating object on the surface of the water • as the ripple moves past the object moves up and down • it does not move forward, showing that the wave does not transfer water • you can show that sound waves do not transfer air by putting a candle/suspending a very light ball in front of a loudspeaker • as the sound wave moves through the candle/ball moves backwards and forwards • it does not move forward, showing that the wave does not transfer air			
06.1	light from the flash of the gun travels instantaneously/very fast/takes no time to reach the scientist		1	AO2 4.6.1.2
06.2	distance between him and the gun time between seeing the flash of the gun and hearing the sound		1 1	AO1 AO2 4.6.1.2
06.3	fractional difference= $\frac{478.4 - 340}{340}$ $= \frac{138.4}{340}$ = 0.41 $0.41 \times 100 = 41\%$		1 1 1	AO2 4.6.1.2

	Answers	Extra information	Mark	AO / Specification reference
06.4	the cannons are 29 000 m apart speed = $\frac{\text{distance}}{\text{time}}$ $332 = \frac{29000}{\text{time}}$ time = $\frac{29000}{332}$ =87(.3) s		1 1 1 1	AO1 AO2 4.6.1.2
06.5	may be much longer time period as 29 km distance very long but original distance not quoted so reaction time produces less error/easier to make precise measurement of a long time interval.	<u>alternative:</u> both measurements are sound not one light and one sound, not relying on long distance vision/hard to see flash at distance	1 1	AO3 4.6.1.2
07.1	the wires are connected to a power supply, and are close to water /exposed wires in contact with water can cause a shock ensure wires are insulated and not in contact with the water.		1 1	AO2
07.2	frequency (Hz) wavelength (m)	units must be included in each case for the marks	1 1	AO1 AO2 4.6.1.2

	Answers	Extra information	Mark	AO / Specification reference
07.3	frequency: number of waves passing a point and divide by 10 **or** = $\frac{5}{10}$ = 0.5 Hz the frequency is the number of waves per second. wavelength: divide 0.2 m by 15 **or** = $\frac{0.2}{15}$ = 0.013 m the wavelength is the distance between two points on the same wave.		1 1 1 1	AO2 4.6.1.2
07.4	speed = frequency × wavelength	accept v = fλ or correct rearrangements	1	AO1
07.5	frequency = $\frac{5}{10}$ = 0.5 Hz wavelength = $\frac{0.2}{15}$ = 0.0 133 m wave speed = 0.5 × 0.0 133 = 7 × 10^{-3} m/s (0.0 067) the smallest number of significant figures given in the question data is 1 (5 waves)	one mark for giving answer to one significant figure and one mark for giving it in standard form	1 1 1 2 1	AO2 4.6.1.2
08.1	one mark for drawing normal and barrier one mark for ray at 30° to normal in and out (by eye or labelled) one mark for wave fronts drawn at 90° to the ray one mark for same wavelength for incident and reflected waves (wave fronts same distance apart)		4	AO1 AO2 4.6.1.3
08.2	energy is transferred to the barrier energy is related to amplitude		1 1	AO2 4.6.1.3

	Answers	Extra information	Mark	AO / Specification reference
08.3	any suitable example, e.g., you can hear people in the next room talking through the wall		1 1	AO2 4.6.1.3
08.4	the frequency stays the same the wavelength increases		1 1	AO1 AO2 4.6.1.3
09.1	the condition of the road affects the frictional force between the tyres and the road/icy road means less friction friction allows the car to stop/so car has bigger braking distance when icy		1 1	AO1 AO2 4.5.6.3.3
09.2	thinking distance is the distance the car travels while the driver is reacting if the speed is bigger the car travels further in his reaction time braking distance is the distance travelled while the car is braking if the speed is bigger car travels further if the braking force is the same		1 1 1 1	AO1 4.5.6.3.1 4.5.6.3.2 4.5.6.3.3
09.3	graph A for a given speed the stopping distance is bigger		1 1	AO2 4.5.6.3.3
09.4	thinking distance = speed x time = 22.3 x 0.4 = 8.9 (2) m thinking distance does not depend on the condition of the road so it is the same for both surfaces. stopping distance for icy road = 80m and for dry road = 50 m braking distance = stopping distance - thinking distance icy road = 80 - 8.9 = 71(.1) m dry road = 50 - 8.9 = 41(.1) m	reading stopping distances off the graph	1 1 1 1 1 1	

	Answers	Extra information	Mark	AO / Specification reference
10.1	(in one minute, or 60 s) the runner travels 180 × 2.0 m = 360 m speed = $\frac{\text{distance}}{\text{time}}$ = $\frac{360}{60}$ = 6 m/s		1 1 1	AO2 4.6.1.2
10.2	stride length		1	AO3 4.6.1.2
10.3	number of strides per minute frequency is the number of waves per unit length		1 1	AO3 4.6.1.2
10.4	in question **10.1**, to work out the speed you multiplied the number of strides per minute/per second by the stride length which is equivalent to multiplying frequency by wavelength which is the same as using the wave equation		1 1 1	AO3 4.6.1.2
10.5	a wave can be reflected, refracted, transmitted or absorbed when it hits a boundary between two media discussion of two issues with modelling the above phenomena e.g., a person could not easily model reflection because they would need to bounce off at equal angles a person cannot be refracted/absorbed by a boundary	list of possible things that happen at a boundary, stated or implicit	1 1 1	AO3 4.6.1.3
11.1	one wave in five squares each square is 0.1 ms period = 5 x 0.0 001 = 5×10^{-4} s	answer given in standard form	1 1 1	AO1 AO2 4.6.1.2

	Answers	Extra information	Mark	AO / Specification reference
11.2	speed = frequency × wavelength	accept v = fλ or correct rearrangements	1	AO1
11.3	frequency = $\frac{1}{\text{period}}$ = $\frac{1}{5\times10^{-4}}$ = 2000 Hz 340 = 2000 × wavelength wavelength = $\frac{340}{2000}$ = 0.17 m		1 1 1	
11.4	amplitude = 3 squares 3 × 2 V per square = 6 V		1 1	AO1 AO2 4.6.1.1
12.1	independent: length (of ruler) dependent: deflection control variable: **two** from • mass • position of mass • type of ruler	one mark for each correct answer up to a maximum of two marks	1 1 2	AO2 4.5.3

	Answers	Extra information	Mark	AO / Specification reference
12.2	appropriate method, e.g., • fixed another ruler behind the ruler and measure the deflection • change the length of the ruler a number of times and measure again • repeat the experiment three times for each length, take the average of repeat readings	one mark for method of measuring deflection one mark for measuring deflection and change length one mark for repeating measurements/calculating means	3	AO1 4.5.3
12.3	if the deflection is proportional to the length, then doubling the length should double the deflection looking at results for lengths of 0.2 m and 0.4 m, the deflection increases from 3.5 to 4.2, which is not double.		1 1	AO3 4.5.3
12.4	for example: • how does the mass affect the deflection of the ruler? • how does the position of the mass affect the deflection of the ruler?	accept any sensible suggestion	1	AO2 4.5.3
13.1	zero		1	AO2 4.5.6.1.3
13.2	distance = 4.5 × 1609 = 7240.5 (m)	accept 7241	1	AO1
13.3	distance = 7240.5 × 2 = 14 481 m time = 20 min × 60 s = 1200 s speed = $\frac{\text{distance}}{\text{time}}$ = $\frac{14480}{1200}$ = 12(.07) m/s	allow error carried forward	1 1 1 1	AO1 AO2 4.5.6.1.2

	Answers	Extra information	Mark	AO / Specification reference
13.4	the speed varies over the journey, but the calculation uses total distance/total time which gives average speed		1	AO2 4.5.6.1.2
14.1	5 miles = 5 × 1609 = 8045 m 1 hour = 3600 s 5 mph = $\frac{8045}{3600}$ = 2.23 m/s		1 1 1	AO1 AO2 4.5.6.1.2
14.2	acceleration = $\frac{\text{change in velocity}}{\text{time}}$	accept a = Δv/t or correct rearrangement	1	AO2 4.5.6.1.2
14.3	a = $\frac{2.2}{5.0}$ = 0.44 m/s^2		1 1	AO2 4.5.6.1.5
14.4	force = mass × acceleration	accept F = ma or correct rearrangement	1	AO1
14.5	F = 1250 × 0.44 = 550 N		1 1	AO2 4.5.6.2.2
14.6	constant speed – driving and resistive forces are equal. acceleration – driving force is bigger than the resistive forces resistive forces increase with speed		1 1 1	AO1 AO2 4.5.6.2.1 4.5.6.2.2