Question	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		1	AO1 AO2 4.6.1.2
01.3	move hand up and down a smaller 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

Question	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	method of deciding proportionality explicitly stated or implicit	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 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

Question	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 = f λ 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 comment.		0	

Question	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 × 100 = 41%	either showing × 100 in calculation or finding decimal and multiplying by 100	1 1 1	AO2 4.6.1.2

Question	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.	alternative: 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 for each mark	1 1	AO1 AO2 4.6.1.2

Question	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 = f λ 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 answer to one significant figure one mark for standard form	1 1 1 2 1	AO2 4.6.1.2
08.1	independent: length (of ruler) dependent: deflection control variable – **two** from mass, position of mass, type of ruler		1 1 2	AO2 4.5.3

Question	Answers	Extra information	Mark	AO / Specification reference
08.2	appropriate method, e.g., • fix 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		1 1 1	AO1 4.5.3
08.3	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
08.4	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
09.1	zero		1	AO2 4.5.6.1.3
09.2	distance = 4.5 × 1609 = 7240.5 (m)	accept 7241	1	AO1
09.3	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		1 1 1 1	AO1 AO2 4.5.6.1.2
10.1	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

Question	Answers	Extra information	Mark	AO / Specification reference
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 time		1 1	AO3 4.6.1.2
10.4	in part (a), to work out the speed, you multiplied the number of strides per minute by the stride length which is equivalent to multiplying the frequency by wavelength which is the same as using the wave equation		1 1 1	AO3 4.6.1.2
11.1	one wave in five squares each square is 0.1 ms period = 5 x 0.0 001 $= 5\times10^{-4}$ s		1 1 1	AO1 AO2 4.6.1.2
11.2	speed = frequency × wavelength	accept $v = f\lambda$ 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	AO2 4.6.1.2

Question	Answers	Extra information	Mark	AO / Specification reference
11.3	amplitude = 3 squares 3 squares × 2 V per square = 6 V		1 1	AO1 AO2 4.6.1.1
12.1	the time for one complete wave		1	AO1 AO2 4.6.1.2
12.2	time period = 1 millisecond = 0.001 s frequency = $\frac{1}{\text{time period}}$ = $\frac{1}{0.001}$ = 1000 Hz	allow 10^{-3} s	1 1 1	AO2 4.6.1.2
12.3	speed = frequency × wavelength	allow v =fλ or correct rearrangements	1	AO1
12.4	speed = 1000 Hz × 0.34 m = 340 m/s		1 1	AO2 4.6.1.2
13.1	voltmeter		1	AO2 4.2.1.3
13.2	potential difference = current × resistance	allow V = IR or correct rearrangements	1	AO1

Question	Answers	Extra information	Mark	AO / Specification reference
13.3	potential difference = 0.15 × 10 = 1.5 V	allow 1.5 with no substitution for two marks	1 1	AO1 4.2.1.3
13.4	charge = current × time	allow Q = It or correct rearrangements	1	AO1
13.5	charge = 0.15 × 60 = 9 C/coulombs		1 1 1	AO1 AO2 4.2.1.2
13.6	it would increase the potential difference has increased (but the clock resistance is the same)		1 1	AO1 AO2 4.2.1.3
14	**Level 3**: Well organised answer with descriptions of reasons for calculations. Equations for power, efficiency and gravitational potential energy used.		5-6	AO1 AO2 4.1.1.2 4.1.1.4
	Level 2: Some relevant calculations, but descriptions lacking detail or missing, or parts of calculations/conversions incorrect.		3-4	
	Level 1: Some relevant calculations completed, but unit conversions may be missing and no explanation of method.		1-2	
	No relevant content.		0	

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Specification reference</th></tr>
<tr><td></td><td>Indicative content:
• calculate energy needed to be transferred to bulb:
○ energy = power × time
○ = 0.24 × 60
○ = 14.4 J
• energy transferred to motor must be greater than this because the generator is only 90% efficient
○ efficiency = $\frac{\text{energy out}}{\text{energy in}}$ x 100
○ 90 = $\frac{14.4}{\text{energy in}}$ x 100
○ energy in = $\frac{14.4}{90}$ x 100
○ = 16 J
• this energy is transferred by the falling mass
○ gravitational potential energy = mass × gravity × height
○ 16 = 0.3 × 9.8 × height
○ height = 5.4 m</td><td></td><td></td><td></td></tr>
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