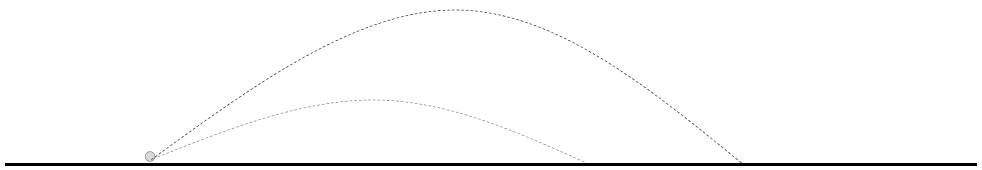
Question Number	Answer		Mark
1(a)(i)	Use of trig to find the vertical **Or** horizontal component of the initial velocity	**(1)**	
	Use of suitable equations of motion to calculate total time of flight of the ball	**(1)**	
	Use of $v = s/t$	**(1)**	
	Total horizontal distance travelled = 98 m to 101 m	**(1)**	
	<u>Example of calculation</u> $u_v = 35 \text{ m s}^{-1} \sin 26° = 15.3 \text{ m s}^{-1}$ $t_{½} = \frac{0 - 15.3 \text{ m s}^{-1}}{-9.81 \text{ m s}^{-2}} = 1.56 \text{ s}$ $t_{total} = 3.12 \text{ s}$ $s = 35 \text{ m s}^{-1} \cos 26° \times 3.12 \text{ s} = 98.1 \text{ m}$		**4**
1(a)(ii)	Trajectory with a greater max height **and** a greater range	**(1)**	
	<u>Example of diagram</u> 		**1**
1(b)	**Air resistance:** Decreases the time (of flight) **Or** increases the deceleration of the golf ball as it rises **Or** decreases the horizontal velocity **Or** unbalanced force acting horizontally	**(1)**	
	Decreases (horizontal) distance travelled	**(1)**	
	Upwards force: Increases the time of flight **Or** decreases the deceleration of the golf ball as it rises	**(1)**	
	Increases (horizontal) distance travelled	**(1)**	**4**
	Total for Question		**9**

Question Number	Answer	Mark
2(a)(i)	Superposition/interference between waves travelling in opposite directions (from open end and wave reflected at closed end) **(1)** At node the waves are in antiphase, so there is destructive interference **Or** At the antinode they are in phase so there is constructive interference **(1)** At an antinode there is maximum <u>amplitude</u> **Or** At a node there is zero <u>amplitude</u> **(1)**	**3**
2(a)(ii)	Show a pattern of alternating nodes and antinodes, labelled or waveform, with node at closed end **(1)** Show a pattern of alternating nodes and antinodes, labelled or waveform, with antinode at open end **(1)** frequency consistent with a correct pattern e.g NANA = 1230 Hz or NANANA = 2050 Hz **(1)**	**3**
2(b)	Records frequency from the graph (375 Hz, 1150 Hz, 1900 Hz) **(1)** Determines wavelength for chosen frequency 375 Hz: 4 × tube length (= 81.2 cm) 1150 Hz: 4/3 × tube length (= 27.1 cm) 1900 Hz: 4/5 × tube length (= 16.2 cm) **(1)** use of $v = f\lambda$ **(1)** v = 305 m s^{-1} **(1)** <u>Example of calculation</u> wavelength = 4 × tube length = 81.2 cm $v = f\lambda$ = 375 Hz × 0.812 m = 305 m s^{-1}	**4**
	Total for question	**10**

Question Number	Answer	Mark
3(a)	Use of distance = speed × time **(1)** Correct use of factor 2 **(1)** Distance = 7.7 m **(1)** <u>Example of calculation</u> Distance = 340 m s^{-1} × 0.045 s / 2 = 7.65 m	**3**
3 (b)	<u>Higher frequency:</u> Higher frequency gives a shorter wavelength **(1)** So there is less diffraction (and the reflected intensity is higher) **Or** Allowing greater detail from the returned pulses **(1)** <u>Shorter pulse duration:</u> Shorter pulses have a shorter length **(1)** So they locate the prey more precisely **Or** allow greater detail **Or** allows a shorter return time so overlapping of reflected and emitted pulses is prevented **(1)** <u>Separated by a shorter time interval:</u> Separated by a shorter time (because the prey is closer) so the pulses travel a smaller distance and they return more quickly **(1)** So the reflected pulses don't overlap with the emitted pulses **Or** to allow more frequent monitoring of the prey's position **(1)** (max 1 mark for unqualified 'greater detail')	**6**
3(c)	Doppler effect causes change in wavelength / frequency **Or** States (relative) motion of source (and observer) causes change in wavelength / frequency **(1)** If the frequency is increased (the bat can tell that) the prey is moving towards (it) **(1)** If the frequency is decreased (the bat can tell that) the prey is moving away from (it) **(1)** Accept, in place of MP2 or MP3, the frequency change is proportional to the velocity so the bat can deduce the speed of the prey	**3**
	Total for question	**12**

Question Number	Answer	Mark
4(a)	To be able to distinguish which reflection comes from which emission **Or** so one pulse returns before the next one is emitted **(1)**	**1**
4(b)	Use of $v = s/t$ **(1)** Correct use of factor of 2 (double distance or double time) **(1)** Pulse duration = 2.4×10^{-3} s (0.0024 s, 2.4 ms) **(1)** Example of calculation Time = 2×0.4 m $\div$ 330 m s^{-1} Pulse duration = 2.4×10^{-3} s	**3**
4(c)	(Ultrasound) reflected away from the sensor **Or** (Ultrasound) reflected towards the floor **(1)**	**1**
	Total for Question	**5**

Question Number	Answer	Mark
5	Oscillations/vibrations of (air) particles/molecules/atoms **(1)** Oscillations/vibrations/displacement parallel to direction of propagation **Or** Oscillations/vibrations/displacement parallel to direction of energy transfer **(1)** (Producing) compressions and rarefactions **Or** regions of high and low pressure **Or** it is a longitudinal wave **(1)**	**3**
	Total for question	**3**

Question Number	Answer		Mark
***6(a**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) **Distance :** Speed of waves known **Or** refers to speed of light Use (distance =) speed × time ÷ 2 **Relative speed**: (Relative) speed indicated by a change in frequency Larger change indicates a greater speed **Amount of rain:** The intensity/amount of reflected signal increases as the amount of rain increases. Reason for the larger signal e.g. larger area, more drops or larger drops	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
6(b)(i)	Pulses, so the reflected signal is received before next one is sent **Or** otherwise there wouldn't be a way of telling which bit of reflected signal originated with which bit of emitted signal **Or** so that reflected pulses can be distinguished from each other (Answers in terms of avoiding interference between two waves / standing waves not accepted)	**(1)**	**1**
6(b)(ii)	Use of $v = s/t$ with $v = 3 \times 10^8$ (m s^{-1}) Selects the smaller distance 5 km $t = 3.3 \times 10^{-5}$ s Example of calculation t = 5000 m × 2 / 3×10^8 m s^{-1} $t = 3.3 \times 10^{-5}$ s (Do not credit answers involving wavelength)	**(1)** **(1)** **(1)**	**3**
	Total for question		**10**

Question Number	Answer		Mark
7(a)	Use of $c = f\lambda$ with $c = 3.00 \times 10^8$ m s^{-1}	**(1)**	
	$\lambda = 1.37$ m	**(1)**	**2**
	<u>Example of calculation</u> $\lambda = 3.00 \times 10^8$ m s^{-1} / 2.186×10^8 Hz $\lambda = 1.37$ m		
7 (b)	Frequency – number of oscillations/vibrations/cycles/waves per second **Or** number of oscillations/vibrations/cycles in unit time (ignore 'complete') (do not accept 1/period, unless period is defined appropriately) [accept number of wavelengths per second]	**(1)**	
	Wavelength – distance travelled during one complete oscillation/vibration/cycle **Or** shortest distance between two points at the same stage of the cycle/in phase **Or** distance between identical points on adjacent waves (Accept distance between adjacent/neighbouring peaks/crests/troughs but not just 'distance between peaks' or 'length of wave')	**(1)**	**2**
	Total for question		**4**

Question Number	Answer		Mark
8 (a)	Particles/atoms/ions/molecules (in metal) oscillate/vibrate	**(1)**	
	Along direction of propagation **Or** parallel to direction of wave travel **Or** in direction of energy transfer (along direction of motion/movement is insufficient)	**(1)**	
	Making compressions and rarefactions **Or** as a longitudinal wave	**(1)**	**3**
8 (b)	Use of $s = vt$	**(1)**	
	Correct application of factor of 2	**(1)**	
	Answer, $s = 0.015$ m **Or** total journey time for thickness 4 cm = 1.4×10^{-5} s	**(1)**	
	Comparison – Steel is corroded because thickness less than 4 cm (allow even if no division by 2) **Or** Steel is corroded because detected time less than for 4 cm (allow even if no division by 2)	**(1)**	**4**
	(For third mark, accept $s = 0.030$ m where final comparison is with total uncorroded journey distance, 8 cm **Or** time = 6.8×10^{-6} s where final comparison is with half of corroded journey time 2.6×10^{-6} s)		
	<u>Example of calculation</u> $s = 5900 \text{ m s}^{-1} \times 5.1 \times 10^{-6}$ s = 0.030 m Thickness = 0.030 / 2 = 0.015 m		
8 (c)	Need to measure time at which the echo arrives back **Or** need to measure time taken for echo to return	**(1)**	
	If continuous couldn't tell when this was **Or** so pulse must return before next is emitted	**(1)**	
	Shorter pulses means smaller thickness can be measured **Or** longer pulses means only larger thickness can be measured	**(1)**	**3**
	Total for question		**10**