Question Number	Answer		Mark
1(a)	**Pulse-echo principle (Max 2 marks)** Pulse reflected at boundary/surface/foetus/where density changes Time for (echo/reflected) pulse to return measured Time (to return) depends on distance/depth **Or** distance calculated from time (to return) (ignore any incorrect description of method) **Practical detail (Max 2 marks)** Many/large number of pulses/distances/times/results Probe moved to different positions/angles (Ultrasound) travels as pulses so that one pulse is detected before the next pulse is sent.	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
1(b)	Involves a moving reflector/surface/boundary/heart/blood (not detector/not source) Refers to a change in frequency/wavelength (Can be descriptive, e.g. causes wavefronts to be compressed when heart moving towards detector) (Assume relative change in frequency or wavelength corresponds to movement unless explicitly incorrect)	**(1)** **(1)**	**2**
1(c)	Use of speed = distance/time Correct use of factor of 2 (thickness × 2 or calculated time × 2) Time = 5.0×10^{-7} s (Time = 2.5×10^{-7} scores 1 mark only for this method) (Method based on $v = f\lambda$ scores no marks.) <u>Example of calculation</u> Distance = thickness × 2 = 5×10^{-4} m × 2 Time = distance /speed t = 1×10^{-3} m /2000 m s^{-1} t = 5.0×10^{-7} s	**(1)** **(1)** **(1)**	**3**
	Total for question		**8**

Question Number	Answer	Mark
2(a)	Diffraction is the spreading out of a wave (not bending, not bending round, not just change in direction) **(1)** as it passes (through) a gap/slit/aperture **Or** passes (around) an obstacle **(1)** (No marks for diagram as it says 'state'.)	**2**
2(b)	Indication that two or more (waves) meet/overlap/coincide **(1)** The (total) <u>displacement</u> at a point is the sum of the individual <u>displacement</u>s **(1)**	**2**
2(c)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Identifies that the rock(s) or gap(s) in the rocks cause diffraction **Or** cause wave(front)s to become curved / waves to spread out **(1)** Waves/wavefronts (from each gap) overlap/meet **(1)** (At some places) waves are in phase (accept path difference equal to whole number of wavelengths) **Or** (at some places) waves are in antiphase (accept path difference equal to whole number of wavelengths plus half a wavelength) **(1)** Constructive superposition/interference occurs **Or** destructive superposition/interference occurs (must correspond to phase differences if referred to elsewhere) **(1)** Maximum/large <u>amplitude</u> erodes beach / disturbs sand the most **Or** minimum/zero <u>amplitude</u> doesn't disturb sand (as much) **Or** reduced <u>amplitude</u> disturbs sand less **(1)**	**5**
	Total for question	**9**

Question Number	Answer		Mark
3(a)	*Transverse* Vibration/oscillation/displacement is perpendicular to direction of wave/energy travel (allow propagation or wave velocity for wave travel) *Longitudinal* Vibration/oscillation/displacement is parallel to direction of wave/ energy travel (allow in the same direction for parallel) Marks can be scored from a clearly labelled diagrams	**(1)** **(1)**	**2**
3(b)(i)	(Pulse) longitudinal Hammer moves horizontally OR parallel to (length of) rod Or Hammer causes compressions in rod	**(1)** **(1)**	**2**
3(b)(ii)	Use of speed = distance/time Use of either 2.4×10^{-4} s **OR** 2.4 m Speed = 5000 m s^{-1} (2500 (m s^{-1}) scores max 1/3 for use of v=d/t) (do not credit method using $v=f\lambda$) <u>Examples of calculation</u> Speed $= \frac{2.4 \text{ m}}{4.8 \times 10^{-4} \text{ s}}$ or $\frac{1.2 \text{ m}}{2.4 \times 10^{-4} \text{ s}} = 5000$ m s^{-1}	**(1)** **(1)** **(1)**	**3**
3(b)(iii)	Vibration/oscillation of (atoms/molecules/particles in) rod/metal	**(1)**	**1**
3(c)	**Max 3** • Idea of reflection (in rod) **OR** two waves travelling in opposite directions • Waves have same frequency /wavelength • Superposition (do not credit superimposition) • Nodes and antinodes produced. (marks can be scored from a labelled diagram)	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**11**

Question Number	Answer	Mark
4	See $c = 3 \times 10^8$ (m s^{-1}) converts MHz to Hz λ = 3.13 m Example of calculation λ = (3×10^8 m s^{-1}) / 95.8×10^6 Hz λ = 3.13 m	**(1)** **(1)** **(1)**
	Total for question	**3**

Question Number	Answer	Mark
5(a)	Wavelength of microwaves < wavelength radiowaves OR statement that wavelength of radiowaves is larger (need some comparison and do not credit frequency) Less / no diffraction **OR** beam spreads out less	 **(1)** **(1)**
5(b)(i)	Frequency (of reflected wave) would be higher	**(1)**
5(b)(ii)	There is a link between frequency (change) and speed(ing) (Car is speeding) when frequency (change) exceeds some limit (answers may be given in terms of wavelength)	**(1)** **(1)**
5(c)(i)	Use of intensity × area × 0.08 energy/sec = 6 J or J s^{-1} or W Example of calculation Energy per second = 500 W m^{-2} × 0.5 m × 0.3 m × 0.08 = 6 J	**(1)** **(1)** **(1)**
5(c)(ii)	Use of $E = Pt$ with any relevant time e.g. 8 hours, 480 min or 28800s t = 28800 s Number of flashes = 1700 Ecf answer to (c)(i) [Take their answer to (c)(i) and multiply by 288 to check their answer for full marks] Example of calculation Number of flashes = (6 × 8 × 3600)/100 =1728	**(1)** **(1)** **(1)**
	Total for question	**11**

Question number	Answer	Mark
6(a)	Doppler	1
(b)	**MAX 3** **Ambulance moving towards,** higher frequency/pitch (1) Wavelength shorter/waves bunch together (1) **Ambulance moving away,** lower frequency/pitch (1) wavelength increased/waves spread out (1) (wavelength marks may be awarded on a diagram)	
		Max 3
(c)	Reference to a higher/lower frequency/wavelength/pitch scores 1 Change in frequency is greater **OR** even higher/ lower frequency **OR** range of frequencies greater scores 2	
		2
	Total for question	**6**

Question Number	Answer	Mark
7(a)	The answer must be clear, organised in a logical sequence and uses specialist vocabulary	
	Interference (pattern) produced / superposition occurs/ standing wave formed	**1**
	Maxima related to constructive interference/antinode **and/or** minima related to destructive interference/node	**1**
	Maxima/antinode formed where the waves are in phase / path difference nλ	**1**
	Minima/node formed where the waves are in antiphase / path difference = (n+½)λ	**1**
	[out of phase is not sufficient]	
(b)(i)	Distance between adjacent maxima = λ/2	**1**
	Wavelength = 0.1 m	**1**
(b)(ii)	Use of $v = f\lambda$ with their λ from (b)(i)	**1**
	Speed = 330 m s^{-1} ecf their λ	**1**
	Example of answer	
	$v = 3300 \times 0.1$	
	$v = 330$ m s^{-1}	
(c)(i) and (ii)	(mark (i) and (ii) as one section	
	(minima never zero) because there is not complete cancellation/overall displacement is not zero/ not total destructive interference	**1**
	Because the waves have different amplitudes/amplitude decreases with distance	
	OR	
	energy loss due to reflection or spreading out	

	OR reflection off other surfaces As the microphone moves towards the plate, the path difference decreases Amplitudes (of waves) get similar	**1** **1** **1**
	Total for question	**12**