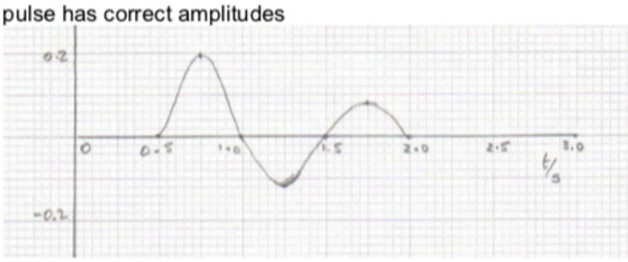
1)

(a)	(i)	*displacement :* (any) distance moved from equilibrium of a point/particle on a wave *amplitude* maximum displacement (caused by wave motion)	**B1** **B1**	**allow** rest, zero, mean position
(a)	(ii)	*frequency* number of wavelengths passing a point /vibrations at a point per unit time/second or produced by the wave source /AW *phase difference* between two points on the same wave/waves of the same frequency, how far through the cycle one point is compared to the other	**B1** **B1**	**allow** number of oscillations / cycles per second **accept** in one second **allow** suitable descriptions of in phase and out of phase; **or** an angular measurement of how much a wave leads or lags/AW
(b)		pulse starts at 0.5 s ends at 2.0 s pulse shape is reversed from Fig 6.1 pulse has correct amplitudes 	**B1** **B1** **B1** **B1**	 ie amplitude decreasing from L to R over 1.5s accept inversion in time axis NB if extra loops, probably only first marking point available if diagram looks like a coiled spring rather than a smooth curve, 1st, 2nd and 4th marking points are possible
		Total	**8**	

2)

a		oscillation/vibration of particles/medium in direction of travel of the wave example: sound wave, etc. oscillation/vibration of particles/medium (in the plane) at right angles to direction of travel of the wave example: surface water waves, string, electromagnetic, etc	B1 B1 B1 B1	**allow** direction of energy transfer of the wave **not** direction of wave motion **allow** direction of energy transfer of the wave **allow** RE mark for weaker descriptions with same omissions as in longitudinal wave
b		the incident wave is reflected at the end of the pipe reflected wave interferes/superposes with the incident wave to produce (a resultant wave with) nodes and/or antinodes	B1 B1 B1	 **QWC mark** **accept** resultant wave with no energy transfer
c	**i**	at 0 oscillation with max amplitude along tube at 0.2 m (oscillation along tube with) smaller amplitude at 0.6 m no motion/node	B1 B1	**not** displacement (penalise only once) all 4 correct for 2 marks; 2 correct for 1 mark
	ii	oscillation at 3 times the frequency of c(i) at 0 (oscillation with) max amplitude (along tube)/antinode at 0.2 m no motion/node at 0.4 m motion as at 0 (but in antiphase/opposite direction)	B1 B1	 3 correct for 2 marks; 2 correct for 1 mark
d	**i**	λ/2 sketch with zero at 0.3 m	M1 A1	**accept** 1 or 2 lines, solid or dotted
	ii	$2f_0$	B1	**no ecf from d(i)**
		Total question 6	**14**	

3)

(a)		travel in a vacuum same speed (in vacuum)/at c caused by accelerating charges are (oscillating) electric and magnetic fields	B1 B1	**max** 2 marks from 4 marking points for any one incorrect property, max of 1/2 if 2 incorrect properties, score 0
(b)		10^{-4} microwaves; 10^{-6} ir; 10^{-8} uv; 10^{-12} gamma	B1 B1	4 correct 2 marks 2 correct 1 mark
(c)	(i)	the incident wave is reflected at the sheet to produce return wave of same frequency/AW reflected wave is weaker **OR** the reflected wave has travelled a greater distance	B1 B1	**accept** incident and reflected waves are from same source/of same wavelength/AW **allow** wave amplitude decreases with distance
(c)	(ii)	reflected wave interferes/superposes with the incident wave constructive interference occurs (**or** waves add) to give maxima/AW **and** destructive interference occurs (**or** waves add) to give minima/AW detail given, e.g. waves add in phase for max/out of phase for min **or** path difference nλ for max (2n +1)/2 λ for min	B1 M1 A1	if incident and reflected waves identified in (c)(i) **accept** "the waves interfere / superpose" **QWC mark** for second marking point **accept** antinodes for maxima and nodes for minima
(c)	(iii)	$\lambda/4 = 7.5$ mm; $\lambda = 30$ mm	B1	
(c)	(iv)	appreciation that I is proportional to a^2 ratio = $(0.8 + 0.6)^2/(0.8 - 0.6)^2$ $= (1.4/0.2)^2 = 7^2 = 49$	C1 C1 A1	
		NOW SCROLL DOWN TO CHECK PAGE 18 IS BLANK		
		Total	**13**	

4)

Question			Expected Answers	M	Additional Guidance
4					
	a		same frequency / period different amplitude / phase	B1 B1	**accept** wavelength / sinusoidal /AW **accept** + sine and – sine for 2 marks
	b		because the waves have a constant phase relationship **or** are continuous and have the same f/period/λ they are coherent	M1 A1	**accept** same phase relationship for 1 mark only
	c		use of 3 ms as period $f = 1/3.0 \times 10^{-3} = 330$ (Hz) using $v = f\lambda$ $340 = 330\lambda$ $\lambda = 1.0(2)$ (m)	C1 A1 C1 A1	**ecf** for f possible e.g. λ = 1020 (m) **accept** 1.03 (m) **no** SF error here
	d	**i**	0	B1	
		ii	1.0 (μm)	B1	**look for** SF error i.e. zero for 1 (μm)
	e	**i**	Intensity α (amplitude)^2 so ratio is $(3/2)^2 = 9/4$ (giving 2.25 I)	C1 A1	**allow** I α A^2
		ii	resultant $A = A_S + A_T = (\pm)\ 1$ so ratio is $(1/2)^2$ giving 0.25 I	C1 A1	**ecf** from **(d)(ii)**
	f	**i**	phase shift of π or 180° required **or** movement of λ/2 1.02/2 = 0.51 (m)	B1 B1	**ecf** from **(c)**; **accept** (2n + 1)/2 λ **accept** 0.50 m
		ii	intensity increases to the maximum value	B1 B1	**accept** quantitative answers, i.e. from 0.25 I to 6.25 I
			Total question 4	**18**	

5)

(a)	**(i)**	f = 1000/2 f = 500 (Hz)	C1 A1	**give** 1 mark for ½ (POT error)
	(ii)	v = fλ giving 340 = 500 x λ λ = 0.68 (m)	C1 A1	**ecf(a)(i)**
(b)		sinusoidal curve of same frequency and amplitude ± cosine curve	B1 B1	**must** be drawn for <u>2 full cycles</u> to score this mark **allow** drawn as sine curve from t = 0.5 ms
(c)		relates to the <u>oscillation</u> of two points on the (same) wave how far 'out of step' one oscillation is from the other/AW λ/4 means a phase difference of 90^o or π/2 (rad)	B1 B1 B1	**accept** vibration **N.B.** statements about oscillations of two waves can only score the third marking point
(d)		sine wave of same frequency with increased amplitude realisation that intensity is proportional to $(\text{amplitude})^2$ giving amplitude increase by √2, i.e.2.8 mm	B1 B1 B1	
(e)	**(i)**	the wave <u>reflected</u> at the end of the pipe <u>interferes/superposes</u> with the incident wave to produce a resultant wave with nodes and antinodes both ends must be antinodes the pipe must be nλ/2 in length for this to happen	 B1 B1 B1 B1	**max** 3 marks
	(ii) 1	air molecules <u>oscillate</u> along the axis of the tube with maximum <u>amplitude</u>	B1 B1 B1	**max** 2 marks; **allow** vibrate; if transverse wave is clearly implied then can only score third marking point
	(ii) 2	no motion/nodal point	B1	**allow** zero displacement/amplitude
		Total	**18**	

6)

a		(micro)waves are <u>reflected</u> (at the metal walls) reflected waves interfere/superpose with the incident waves to produce nodes and antinodes (– a stationary wave pattern)	**B1** **B1** **B1**	**allow** points of constructive and destructive interference
b		X are the points of <u>maximum</u> energy/intensity/amplitude so are antinodes	**M1** **A1**	**allow** displacement in this case
c		measurement = 3 cm **or** λ/2 = 6 cm so λ = 0.12 m c = fλ = 2.5 x 10^9 x 0.12 = 3.0 x 10^8 (m s^{-1})	**B1** **C1** **M1** **A1**	measurement to within ± 1 mm **ecf** measurement, i.e. λ = 4 x measurement there must be a valid calculation shown scores 1 out of final 3 for answer of 1.5 x 10^8 **allow** 1 SF, i.e. 3 x 10^8
		Total	**9**	

7)

i 1	¾ λ with node at closed end and antinode at open end	B1	**allow** poorly proportioned sketches which reach both ends
i 2	all nodes and antinodes drawn in **bi1** correctly labelled N and A only two N and two A present	B1 B1	positions of labels must be accurate to the eye **allow** max of one mark for only 3 out of the 4 labelled
ii	$\lambda/2 = 33$ cm $v = f\lambda = 512 \times 0.66$ $v = 338$ or 340 ($m\ s^{-1}$)	C1 C1 A1	**or** $\lambda/4 = 16.5$ cm **N.B.** an incorrect value of $\lambda/4$ or $\lambda/2$ scores 0/3
i	the pipe is one wavelength long with both ends antinodes so sketch must have 3 antinodes and 2 nodes <u>with reasonably correct proportions</u>	B1	
ii1	256 (Hz)	B1	
ii2	$\lambda/2$ with antinodes at both ends	B1	
iii	v is the same in the pipe at all f/length is fixed = $\lambda_0/2 = \lambda_1$ so as $f_1 \lambda_1 = f_0 \lambda_0$ then $f_1 = 2f_0$ **or** harmonics must have antinodes at both ends of the pipe so <u>next</u> possible pattern is *one wavelength/has 3A and 2N*	B1 B1	**allow** 1 mark for: as $f_1 = 2f_0$ then f_1 is the second harmonic **or** halving the wavelength doubles the frequency
	Total question 5	**17**	