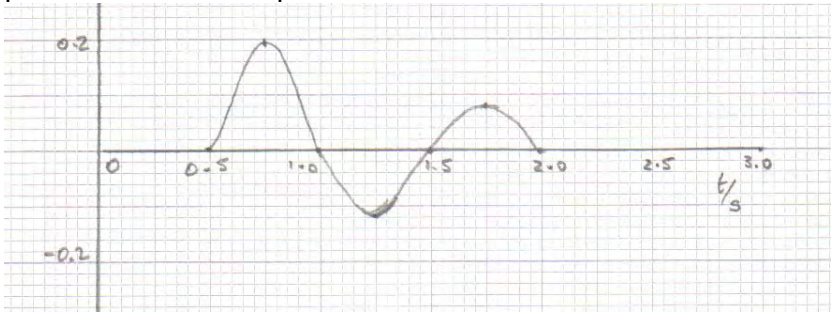
Question			Answer	Marks	Guidance
1	a		all travel at speed of light through a vacuum are oscillating E and B fields **or** are caused by accelerating charges/AW	**B1** **B1**	**max** 2 marks from 3 marking points if 3 properties are given withhold one mark for each incorrect property so 2 correct and 1 incorrect would score 1 mark ;1 correct and 2 incorrect would score zero, etc
	b	**i**	oscillations (of particles/e-m fields along the wave) are in one direction only perpendicular to the direction of wave propagation/of travel of the wave/of energy transfer	**B1** **B1**	
		ii	light passing through polariser 1 is <u>vertically</u> polarised/ only vertical oscillations of the light exist beyond the polariser 1/AW only (the component of) light in the <u>horizontal</u> plane can pass through polariser 2 so no light reaches the eye	**B1** **B1**	**allow** any words indicating <u>vertical</u>, e.g. up and down; for <u>horizontal</u>, e.g. at 90^o to vertical or crossed polarisers **accept** using Malus' law $I_{trans} = I_{incident}\cos^2\theta$ with $\theta = 90^o$ gives $I_{trans} = 0$
		iii	after polariser 1 the component of the vertically polarised light at 45^o passes through polariser 3 the polarised light beyond polariser 3 has a component at 45^o which passes through polariser 2 so light reaches the eye **or mark a typical answer of the form (max 2) as follows** some of the vertically polarised light passes through polariser 3 and some of this passes through polariser 2 because in each case the polarised light is not at right angles to the transmission axis of the polariser	**B1** **B1** **B1**	**QWC** statement to the effect that component of light along polarising axis of filter is transmitted **accept** using Malus' law $I_{trans} = I_{incident}\cos^2\theta$ with $\theta = 45^o$ gives $I_{trans} = I_{incident}/2$ same process gives $I_{trans} = I_{incident}/2$ again so ¼ of light after polariser 1 reaches eye (assuming no absorption) accept answers in terms of amplitudes rather than intensities, i.e. $A = A_0 \cos\theta$, etc.
			Total	**9**	

Question			Answer	Marks	Guidance
2	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** $\lambda/2$ = 6 cm so λ = 0.12 m $c = f\lambda = 2.5 \times 10^9 \times 0.12$ $= 3.0 \times 10^8$ (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 1.5×10^8 **allow** 1 SF, i.e. 3×10^8
			Total	**9**	

Question			Answer	Marks	Guidance
3	(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
A **A** **A**	(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**	

Question			Answer	Marks	Guidance
4	(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 <u>of same frequency</u>/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
A A A	(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 <u>incident</u> and <u>reflected</u> 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)	λ/4 = 7.5 mm; λ = 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	

Question			Expected Answers	M	Additional Guidance
5					
	a	**i**	0.60 m	B1	**allow** 0.6 another example of SF comment Q2
		ii1 **ii2**	the wave has moved along 0.5 wavelengths in 0.75 ms so will move one wavelength in 1.5 ms which is the period/AW f = 670 Hz so v = fλ = 670 x 0.60 = 400 (m s^{-1})	 B1 C1 A1	can be answered in terms of phase **ecf(a)(i)** **accept** v = λ/T = 0.60/1.5 x 10^{-3}
	b		0	B1	
	c	**i**	*displacement* any distance moved from equilibrium of a point/particle (on a wave) *amplitude* <u>maximum</u> possible <u>displacement</u> (caused by wave motion)	 B1 B1	**allow** alternatives for equilibrium, e.g. mean/rest/undisturbed position
		ii	*progressive* a wave which transfers energy *stationary* a wave which <u>traps/stores</u> energy (in pockets) **OR** *progressive* : transfers shape/information from one place to another *stationary* where the shape does not move along/which has nodes and antinodes/AW	B1 B1 B1 B1	**accept** phase relationship descriptions between different points on wave; must be a comparison for same property to score both marks
	d	**i**	the incident wave is <u>reflected</u> at the fixed ends of the wire reflected wave <u>interferes/superposes</u> with the incident wave to produce a resultant wave with nodes and antinodes/no energy transfer	B1 B1 B1	must have reference to an end of the wire QWC mark
		ii1 **ii2** **ii3**	0.70 (mm) 0.15 (m)/0.45 (m) x = 0.2, y = -1.7	B1 B1 B1	**allow** 0.60 to 0.80 mm anywhere on vertical line x = 0.15 or 0.45
			Total question 5	**15**	