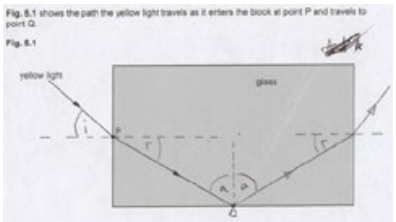
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			**A**	1	**Examiner's Comments** Candidates performed well on this question as they determined that when a wave passes through a gap with a similar size to its wavelength, it results in greater diffraction to give the response A.
			Total	**1**	
2			**A**	1	**Examiner's Comments** Some candidates correctly identified that the ray would follow path A after arriving at point P. To determine the correct path that the ray of light would follow, candidates were required to calculate the critical angle from the refractive index of the glass block to give 42°. If candidates calculated the critical angle they could determine that Total Internal Reflection would occur (as angle of incidence > critical angle) and hence that the ray would follow path A. The most common distractors were answers C and D.
			Total	**1**	
3	a	i	510 (THz)	B1	**Allow** correct answer in answer space **Examiner's Comments** Most candidates were able to calculate the frequency, however, many candidates did not allow for the table heading in THz. **Assessment for learning** Candidates should be able to record data in a table using the units given in the column headings.

		ii	<table><tr><th>Glass</th></tr><tr><td>1.97×10^8</td></tr><tr><td>387</td></tr><tr><td>510</td></tr></table> One correct scores one mark All correct and in the table scores two marks	B1 B1	**Allow ECF** for wavelength for correct speed of wave / same frequency as **(a)(i)** **Allow** 386, for 387 **Allow** 2sf answers, e.g. <table><tr><td>2.0×10^8</td></tr><tr><td>390</td></tr><tr><td>510</td></tr></table> **ECF** from **(a)(i)** **Ignore** units in table **Examiner's Comments** Most candidates were able to calculate the speed of light in glass correctly. Lower scoring candidates often incorrectly believed that the frequency (as opposed to the wavelength) decreased in glass. **Misconception** Many candidates did not fully understand effects of refraction on the quantities speed, frequency, and wavelength.
	b	i	Normal drawn 90° to the surface at P (by eye) **and** angle between normal and incident ray labelled *i* **and** angle between normal and refracted ray labelled *r*	B1	**Examiner's Comments** This was generally answered well with many candidates adding a labelled normal line. Some lower scoring candidates did not draw a normal and just marked the angles between the rays and the boundary of the two mediums.
		ii	Any **four** from: • Use a single slit / yellow filter (in the ray box) • Use of dim lighting / darkened room • Draw around the glass block	4 x B1	**Examiner's Comments** This question was designed to give candidates the opportunity of describing a practical technique. In this question, the basic set-up required a single slit and a yellow filter in the ray-box to produce the thin ray

			• Use a protractor to measure 90° for the normal OR to measure angles • Draw crosses / use pins (a long way apart) on the <u>incident</u> ray / mark incident ray (with ruler) • Mark point Q • (Remove block and) then join P to <u>marked</u> point Q		of yellow light. It is often easier to carry out this experiment in a darkened room. Few candidates gave details of how the rays would be traced and the need to draw the outline of the glass block. High scoring candidates often included detail about placing small crosses on the rays and then using a rule joining them together and removing the block to join points P and Q. Some candidates also discussed the drawing of the normal and using a protractor to measure the angles. **Assessment for learning** Students should have the opportunity of developing their practical skills so that they are able to describe methods and suggest improvements to obtain accurate data.
		iii	$\sin r = \frac{\sin 49.9}{1.52}$ OR $r = \sin^{-1}\left(\frac{\sin 49.9}{1.52}\right)$ OR $\sin r = 0.503$ OR $r = \sin^{-1}(0.503)$	M1 A0	**<u>Examiner's Comments</u>** To gain credit, candidates needed to show the correct substitution of the data into the correct equation and evaluate the answer.
		iv	Angle of incidence, i = (90-30 =) 60° $C = \sin^{-1}\left(\frac{1}{1.52}\right) = 41(°)$ $i > C$	M1 M1 A1	**Allow** 59.8° (use of 30.2°) **Allow** ECF from (b)(iii) **Allow** 60(°)> 41(°) Do not allow 49.9 > 41 **<u>Examiner's Comments</u>** Candidates needed to determine the both the critical angle and the angle of incidence at point Q. Many candidates were able to calculate the critical angle. Since this was a show question it was then expected that there would be an appropriate conclusion that since the angle of incidence (60a) was larger

					than the angle of incidence, total internal reflection would occur. Some candidates showed mathematically that a refracted ray was not possible but did not link this with the criteria for total internal reflection. **Assessment for learning** Candidates should be able to state the conditions for total internal reflection and be able to apply these conditions to practical situations.
		v	Mirror image about vertical plane at Q by eye to where ray leaves the block and bends away from the normal	B1	**Ignore** other lines (since could be due to answering (ii) **Examiner's Comments** The majority of candidates did not realise that there should be a mirror image of the diagram. High scoring candidates answered this question well by adding appropriate lines to the diagram and adding where the angles were equal. **Exemplar 2**  The candidate has clearly shown the answer with the normal lines aligned and labelled the angles so that it is clear which ones are equal. This candidate has also clearly shown the angle of incidence and the angle of refraction for Question 5 (b) (i).
			Total	**13**	

4		i	Transverse because the oscillations / vibrations are at right angles / perpendicular to the direction of travel / energy transfer	B1	**ALLOW** oscillations / vibrations vertical and direction of travel is horizontal **Examiner's Comments** Many candidates incorrectly stated that water waves were longitudinal waves. High scoring candidates referred to oscillations or vibrations of the water particles and the direction of travel of the wave or energy transfer.
		ii	Plane polarised because the oscillations / vibrations are all in the vertical / (only) one plane / direction	B1	**Examiner's Comments** Few candidates were able to explain why the waves were plane polarised. High scoring candidates stated that the oscillations were in the vertical plane only.
			Total	**2**	
5			D	1	**Examiner's Comments** About half of candidates performed well on this question by determining the correct answer of D by understanding the behaviour and intensity of unpolarised light when transmitted through a polarising filter.
			Total	**1**	
6			D	1	**Examiner's Comments** Less than half of candidates answered this question correctly by applying understanding of Total Internal Reflection and the use of sin $C = 1/n$. The most common distractor was C.
			Total	**1**	
7			C	1	**Examiner's Comments** This should have been a straightforward starting question for all

					the candidates in determining the wavelength of microwaves in cm wavelength but less than half of the candidates got the correct answer C. The most common distractor was D.
			Total	**1**	
8			C	1	**Examiner's Comments** A large number of candidates were able to correctly identify the correct response and many drew a diagram to support their answer.
			Total	**1**	
9			B	1	**Examiner's Comments** Candidates performed well on this question as most gave the correct answer B by recognising that sound is an example of a longitudinal wave and electromagnetic waves are an example of transverse waves but that they can both form stationary waves.
			Total	**1**	
10			A	1	**Examiner's Comments** Most candidates performed well as they applied that the greatest moment is produced from force × perpendicular distance of the line of action of the force from P to give the correct answer A.
			Total	**1**	
11			B	1	**Examiner's Comments** Most candidates answered this well as they were able to identify that the intensity was the property that changed when the polarising filter was changed which demonstrated their understanding of plane polarised light.
			Total	**1**	
12			C	1	**Examiner's Comments** Most candidates identified the answer as C by correctly applying Snell's law

					to the boundary of the two materials X and Y.
			Total	**1**	
13			D	1	**Examiner's Comments** This should have been a straightforward starting question for all the candidates in determining a possible wavelength for ultraviolet radiation but only half of the candidates got the correct answer D. The most common distractor was B.
			Total	**1**	
14	a		1.97×10^8 and 2.05×10^8	B1	in that order **Examiner's Comments** This question was well answered with most candidates giving answers correct to three significant figures by using standard form.
	b		$\sin C = \frac{1}{1.52} = 0.658$ 41(°)	C1 A1	41.1395 or 41.3 **Examiner's Comments** Most candidates clearly demonstrated the method to determine the critical angle. Some candidates incorrectly used 45° rather than 90°. **Assessment for learning** To determine the critical angle, the angle of refraction is 90° so sin 90° = 1.
	c		TIR shown at lower left-hand boundary with ray turned through 90° and horizontally to the lower right-hand boundary (by eye) TIR shown at lower right-hand boundary with ray returning vertically parallel to incident ray (exiting glass block) (by eye)	M1 A1	Candidates needed to realise that the angle of incidence was 45° which was greater than the critical angle. So, the total internal reflection occurs at the first surface. No marks were given for candidates who drew any rays that showed refraction. Candidates who scored the first mark invariably realised that the angle of incidence at the second boundary was also 45° so again drew a totally

					internally reflect ray parallel to the incident ray. Rays should be straight and therefore drawn with a ruler. A significant number of candidates omitted this question.
	d	i	sin $C = \frac{1.46}{1.52} = 0.961$ 74 (°)	C1 A1	73.8 **Examiner's Comments** Candidates found this question challenging. Good candidates used the two refractive indexes 1.42 and 1.52 correctly. Many candidates incorrectly used an angle of 45° or 41° rather than 90°. A significant number of candidates omitted this question.
		ii	Ray bends away from the normal (by eye)	B1	**Note** no ECF from (d)(i) **Examiner's Comments** Candidates often did not draw a refracted ray. Of those candidates who gained the answer to the previous part correctly, many did not realise that the ray would bend (slightly) away from the normal. A significant number of candidates omitted this question.
			Total	**8**	