AQA GCSE Physics | 8463

SPECIFICATION POINT 4.6.2.2

Properties of electromagnetic waves 1

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**19**
Available paper years	**2007–2024**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.6.2.2 Properties of electromagnetic waves 1

Answer 01 · Mark scheme

January 2007 | PHY1H | Original Q5 | Legacy

No matching mark scheme was available in the supplied archive for this question.

4.6.2.2 Properties of electromagnetic waves 1

Answer 02 · Mark scheme June 2008 | PHY3H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
(a)(i)	(angle of) refraction	take care **not** to credit 'angle of reflection'	1
(a)(ii)	normal	do **not** credit 'horizontal'	1
(b)	**either** (photographic) <u>film</u> **or** CCD(s) (charge-coupled device(s)) / CMOS(s) (sensor(s)) / (active) pixel sensor(s)	 accept 'LDR(s)' / 'light dependent resistor(s)' **not** lux meter do **not** accept light sensor(s)	1
(c)(i)	converging	**or** 'convex'	1
(c)(ii)	 **either** (0).35 **or** (0).4(1…)	do **not** give any credit for an answer greater than 1 **or** 7 ÷ 20 for **1** mark **or** clear evidence that appropriate measuring / counting, has been made for **1** mark	2
(d)	otherwise it will have no effect on the light detector **or** otherwise no (real) light will fall on the light detector	**or** 'a virtual / imaginary image will have no effect on the light detector' allow error carried forwards for 'light detector' allow so it can be formed on the film	1
total			7

4.6.2.2 Properties of electromagnetic waves 1

Answer 02 · Mark scheme June 2008 | PHY3H | Original Q1 | Legacy

PHY3H

Answer 03 · Mark scheme November 2008 | PHY1BP | Original Q5 | Legacy

Five	**3**	**2**	**1**	**2**

4.6.2.2 Properties of electromagnetic waves 1

Answer 04 · Mark scheme

Question 3

question	answers	extra information	mark
3(a)	the <u>normal</u>		1
3(b)	v		1
3(c)	any **one** from: • light has moved from glass to air / from air to glass • speed of light has changed • angle of incidence is less than the critical angle • change in density (of medium)	 accept light has changed medium beware of contradictions for this marking point eg light has moved from glass to air and slowed down gets zero **or** (angle) i < (angle) c **or** (angle) y is less than the critical angle eg glass is more (optically) dense than air	1

Question 3 continues on the next page . .

4.6.2.2 Properties of electromagnetic waves 1

PHY3H

Question 3 continued . . .

question	answers	extra information	mark
3(d)(i)	ratio of v to y does not give the same answer (in every case) **or** value of v doubles value of y does not double **or** increments for v are the same but increments for y are not the same	allow for **1** mark a calculation but no conclusion eg 30 → 60 19 → 35 (38)	2
3(d)(ii)	as (angle) v increases, angle y increases	accept as the angle of incidence increases, the angle of refraction increases **or** there is a (strong) positive(non-linear) relationship between the variables **or** ratio of sines is constant do **not** accept angle y is not directly proportional to angle v	1
3(d)(iii)	no evidence outside this range **or** when angle y is greater than the critical angle total internal reflection occurs	OWTTE	1
Total			**7**

4.6.2.2 Properties of electromagnetic waves 1

Answer 04 · Mark scheme

June 2009 | PHY3H | Original Q3 | Legacy

PHY3H

4.6.2.2 Properties of electromagnetic waves 1

Question 3

question	answers	extra information	mark
3(a)(i)	microwaves		1
3(a)(ii)	can pass through the ionosphere	accept travels in a straight line accept atmosphere for ionosphere do **not** accept air for ionosphere	1
3(b)	any **two** from: • analogue is continuously varying • digital has only discrete values • digital is less prone to interference (than analogue) • digital can be processed more easily (than analogue) by a computer	 do **not** accept analogue has many values accept digital is on or off accept digital is 1 or 0 accept digital is binary accept digital is easier to restore	2
3(c)	higher the frequency, further the wave travels (into the atmosphere before reflection)		1
3(d)	15 000	allow **1** mark for correct transformation and substitution ie $\frac{300\,000\,000}{20}$ an answer of 15 000 000 only gains **1** mark allow both marks for an answer of 15 MHz (unit must be changed) an answer of 15 gains no credit	2
Total			**7**

4.6.2.2 Properties of electromagnetic waves 1

Answer 05 · Mark scheme

January 2010 | PHY1H | Original Q3 | Legacy

PHY1H

Answer 06 · Mark scheme

March 2011 | PHY1BP | Original Q3 | Legacy

Three	**A**	bacteria	**3**
	B	cells	**2**
	C	isotopes	**1**
	D	particles	**4**

4.6.2.2 Properties of electromagnetic waves 1

Answer 07 · Mark scheme

June 2011 | PHY1H | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)(i)	microwave(s)		1
3(a)(ii)	has discrete values only **or** has only 2 states	accept can only be on or off accept made up of 1 and 0 only accept has high and low (values only) accept a diagram with discrete levels do **not** accept can be switched on and off	1
3(a)(iii)	any **one** from: • less (prone to) interference • can be (easily) processed by computers • better quality (signal) • digital signals can be restored • information / data can be compressed	it refers to signal accept no interference accept interference causes less / no permanent damage accept noise / distortion for interference accept can be processed without an analogue to digital converter better on its own is insufficient accept can send more information in same time do **not** accept faster	1

Question 3 continues on the next page

4.6.2.2 Properties of electromagnetic waves 1

PHY1H

Question 3 continued

question	answers	extra information	mark
3(b)	2 000 000 000	allow **1** mark for correct transformation and substitution ie $\frac{300\,000\,000}{0.15}$ or $\frac{300\,000\,000}{15}$	2
	hertz	accept Hz do **not** accept hz accept kHz / MHz / GHz **but** for full credit the answer and unit must be consistent eg answers 2 GHz; 2000 MHz; 2 000 000 kHz gain **3** marks	1
3(c)(i)	infra red (radiation)	accept IR ignore reference to light	1
3(c)(ii)	travel a shorter distance	do **not** accept faster	1
Total			**8**

4.6.2.2 Properties of electromagnetic waves 1

Answer 07 · Mark scheme June 2011 | PHY1H | Original Q3 | Legacy

PHY1H

4.6.2.2 Properties of electromagnetic waves 1

Answer 08 · Mark scheme

January 2013 | PH1HP | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)	refracted into the block, angle r < i refracted correctly out of block, two rays in air parallel	 judge by eye if first mark not scored allow **1** mark for correct refraction shown as ray leaves the block	1 1
4(b)(i)	the angle of refraction is (always) less than the angle of incidence the angle of refraction increases as the angle of incidence increases	 accept angle i and angle r are **not** directly proportional accept there is positive correlation	1 1
4(b)(ii)	(for the same angle of incidence) the angle of refraction in plastic is less than the angle of refraction in water	accept (for the same angle of incidence) plastic refracts light more than water accept it is less	1
4(c)(i)	accept any sensible suggestion to do with being able to see inside (during daylight hours) eg able to (see to) work / cook inside	accept to see what they are doing lights up the room is insufficient ignore no need to pay for electricity	1
4(c)(ii)	accept any <u>ethical</u> suggestion, eg • fair access to energy for all • unequal use of energy resources • consequences for the future of decisions made now • damage to global environment affects all	 damage to the environment is insufficient	1
Total			**7**

4.6.2.2 Properties of electromagnetic waves 1

Answer 08 · Mark scheme

January 2013 | PH1HP | Original Q4 | Legacy

PH1HP

4.6.2.2 Properties of electromagnetic waves 1

Answer 09 · Mark scheme

June 2014 | PH3HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO spec ref
5(a)	CCD / charged coupled device pupil	ignore sensor do **not** allow film do **not** allow iris	1 1	AO1 3.1.4d
5(b)	the eye(ball) being too short the (eye) lens being unable to focus (an image at the retina) **or** the (ciliary) muscles being unable to change the shape of the lens sufficiently	 accept cornea / lens is not curved enough accept lens is not powerful enough **or** too weak accept lens being unable to accommodate	1 1	AO1 3.1.4b
5(c)	0.31(25)	 allow **1** mark for correct substitution, ie $\frac{1}{3.2}$	2	AO2 3.1.4c
5(d)(i)	1.4	 allow **2** marks for $\frac{0.5}{0.358}$ allow **2** marks for 1.39 an answer of 0.72 gains **2** marks allow **1** mark for correct substitution, ie $\frac{\sin 30°}{\sin 21°}$ allow **1** mark for both sine values correctly calculated ie 0.5 and 0.358 ignore any units	3	AO2 3.1.3c

Question 5 continues on the next page . . .

4.6.2.2 Properties of electromagnetic waves 1

Question 5 continued . . .

Question	Answers	Extra information	Mark	AO spec ref
5(d)(ii)	the lenses can be made thinner	allow the lenses / spectacles/ glasses are lighter allow uses less glass	1	
Total			**10**	

4.6.2.2 Properties of electromagnetic waves 1

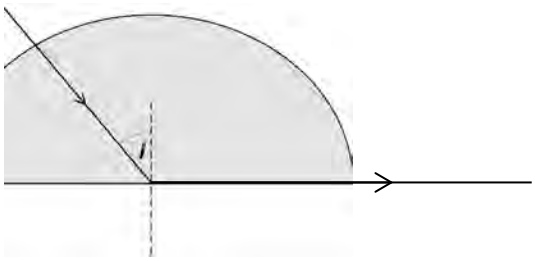
Answer 10 · Mark scheme June 2014 | PH3HP | Original Q7 | Legacy

Question	Answers	Extra information	Mark	AO spec ref
7(a)	because the angle of incidence is greater than critical angle	accept the light is totally internally reflected	1	AO1 3.1.5a
7(b)	41.8	allow **1** mark for correct substitution, eg $1.5 = \frac{1}{\sin c}$ **or** $\sin c = \frac{1}{1.5}$ **or** $c = \sin^{-1}\frac{1}{1.5}$	2	AO2 3.1.5a
7(c)	(for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted	accept for **1** mark: (for both fibres) increasing the wavelength (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission	1	AO3 4.5.3
	(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres) **or** maximum transmission occurs at 6.5 (x 10^{-7} metres)	accept for a further **1** mark: (for both fibres) increasing the wavelength of the light from 5 (x 10^{-7} metres) increases the amount of light transmitted increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own	1	
	the shorter fibre transmits a greater percentage of light (at the same wavelength)	accept for **1** mark: Any statement that correctly processes data to compare the fibres	1	
Total			**6**	

4.6.2.2 Properties of electromagnetic waves 1

Answer 11 · Mark scheme

June 2015 | PH3HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. ref.
6(a)(i)	line drawn at 90 degrees to the normal: 	ignore (partial) reflection of the ray	1	AO1 P3.1.5a
6(a)(ii)	1.5	award both marks for an answer that rounds to 1.5 award **1** mark for correct substitution ie 1 / sin 41 **or** 1 / 0.656(059)	2	AO2 P3.1.5a
6(b)	26	award **3** marks for an answer that rounds to 26 award **2** marks for $1.3 = \frac{0.57(3576)}{\sin r}$ or $r = \sin^{-1}(0.57(3576) / 1.3)$ award **1** mark for correct substitution.ie $1.3 = \frac{\sin 35}{\sin r}$ or sin 35° shown correctly, ie 0.57(3576), or used correctly in the calculation an answer of 0.44 scores 2 marks an answer of 26.9 scores 0	3	AO2 P3.1.3c
Total			6	

4.6.2.2 Properties of electromagnetic waves 1

Answer 11 · Mark scheme

June 2015 | PH3HP | Original Q6 | Legacy



4.6.2.2 Properties of electromagnetic waves 1

Answer 12 · Mark scheme June 2016 | PH3HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
4(a)	angle of incidence: A angle of refraction: D		1	AO1 3.1.3a 3.1.3c
4(b)	42 (degrees)	an answer of 41.8° gains **2** marks an answer that rounds to 42° gains **2** marks an answer of 37 gains **2** marks allow **1** mark for correct substitution i.e. $\sin(c) = \frac{1}{1.5}$ **or** sin(c) = 0.67 provided no subsequent steps	3	AO2 3.1.5a
4(c)	• ray B took longer than ray A (to travel through the optical fibre) • so the pulse spreads out	allow ray B travels further than ray A allow the rays emerge at different times	1 1	AO3 3.1.5b
Total			6	

4.6.2.2 Properties of electromagnetic waves 1

Answer 12 · Mark scheme

June 2016 | PH3HP | Original Q4 | Legacy



4.6.2.2 Properties of electromagnetic waves 1

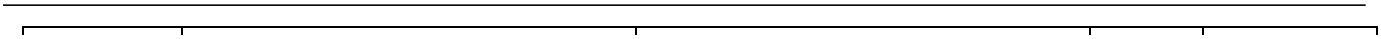
Answer 13 · Mark scheme June 2017 | PH3HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
4(a)	CCD (charge coupled device)	accept CMOS	1	AO1 3.1.4d
4(b)	Converging – both real and virtual images Diverging – virtual image only		1 1	AO1 3.1.3g
4(c)	The refractive index of the converging lens is greater (for all frequencies) The refractive index of the converging lens increases more than that of the diverging lens The refractive index of the converging lens reaches a maximum at a lower frequency than that of the diverging lens	use of data without comparison is insufficient	1 1 1	AO2 3.1.3c
4(d)	An answer that rounds to 12	allow **2** marks for $r = \sin^{-1}(0.21)$ allow **1** mark for correct substitution ie $1.6 = \sin(20)/\sin(r)$ allow **1** mark for $r = \sin^{-1}(\sin(20)/1.6)$ allow **1** mark for 0.21	3	AO2 3.1.3c
4(e)	− 2.5 dioptres / D	allow **1** mark for − 0.025 allow **1** mark for (+) 2.5	2 1	AO2 AO1 3.1.4e
4(f)	curvature refractive index	allow shape allow material it is made from ignore references to density	1 1	AO1 3.1.3g
Total			**14**	

4.6.2.2 Properties of electromagnetic waves 1

Answer 13 · Mark scheme

June 2017 | PH3HP | Original Q4 | Legacy



4.6.2.2 Properties of electromagnetic waves 1

Answer 14 · Mark scheme June 2018 | 8463/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	an idea used to explain observations and data		1	AO1 key ideas
09.2	different models may be appropriate in different situations	allow one particular model may not be able to explain all observations	1	AO1 key ideas
09.3	new (experimental) evidence / data		1	AO1 key ideas
	evidence cannot be explained using an existing model **or** predictions made using old model are shown to be incorrect	allow old model based on data now shown to be incorrect	1	
	new model explains new evidence **or** predictions made with new model are shown to be correct		1	
	a suitable example given eg nuclear model of the atom replacing the plum pudding model	allow tectonic plates replacing static land masses	1	
	big bang theory replacing other theories for the creation of the universe	allow heliocentric model of solar system replacing geocentric model		
09.4	velocity / speed is slower in shallow water		1	AO2 4.6.2.2
	so edge of wave (front) entering shallow water slows down		1	
	but the part of the wave (front) in deeper water continues at a higher speed (leading to a change in direction of the wave fronts)	allow one part of the wave (front) changes speed before other parts allow an answer in terms of wave (front) travelling from shallow to deep water	1	

4.6.2.2 Properties of electromagnetic waves 1

Answer 14 · Mark scheme

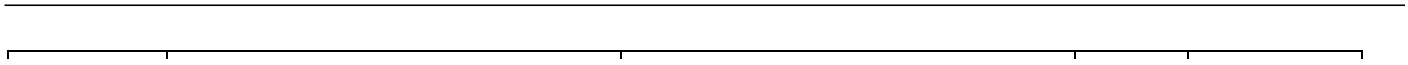
June 2018 | 8463/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	every point on the wave (front) enters / hits the shallow water at the same time and so every point slows down at the same time	 allow changes speed for slows down allow an answer in terms of wave (front) travelling from shallow to deep water	1 1	AO2 4.6.2.2
Total			**11**	

4.6.2.2 Properties of electromagnetic waves 1

Answer 14 · Mark scheme

June 2018 | 8463/2H | Original Q9



4.6.2.2 Properties of electromagnetic waves 1

Answer 15 · Mark scheme

June 2019 | 8463/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
1.1	focal length	this answer only	1	AO1/1 4.6.2.5
1.2	one correct line drawn from the top of the object, passing through the lens and crossing or meeting given line inverted image drawn at the correct position and length	ignore any arrow drawn on the line if two lines are drawn, both must be correct arrowhead required	1 1	AO2/2 4.6.2.5
1.3	similarity (both are) diminished difference concave is <u>virtual</u> and convex is <u>real</u> **or** concave is upright and convex is inverted	 allow smaller for diminished a comparison must be made ignore reference to positions of images	1 1	AO3/2a 4.6.2.5
1.4	 $6.0 = \frac{9.0}{\text{object height}}$ $\text{object height} = \frac{9.0}{6.0}$ object height = 1.5 (mm)	an answer of 1.5 (mm) scores **3** marks provided working can be seen, an attempt to convert 9.0 mm to cm or m with all other steps correct scores **2** marks	 1 1 1	AO2/1 4.6.2.5
Total			**8**	

4.6.2.2 Properties of electromagnetic waves 1

Answer 16 · Mark scheme

November 2020 | 8463/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	it is harder to judge where the centre of a wider ray is		1	AO3 4.6.1.3 RPA9
	causing a larger uncertainty (in the measurements)	allow increasing <u>random</u> errors (in the measurements)	1	
03.2	line of best fit drawn and extrapolated to 80 degrees		1	AO3 4.6.1.3 RPA9
	41 (degrees)	allow 40 to 43 (degrees)	1	
03.3	**Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		5–6	AO1 4.6.1.3 RPA9
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.		3–4	
	Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.		1–2	
	No relevant content		0	
	Indicative content: • place a glass block on a piece of paper • draw around the glass block • use the ray box to shine a ray of light through the glass block • mark the ray of light entering the glass block • mark the ray of light emerging from the glass block • join the points to show the path of the complete ray through the block • and draw a normal line at 90 degrees to the surface • use a protractor to measure the angle of incidence • use a protractor to measure the angle of refraction • use a ray box to shine a ray of light at a range of different angles (of incidence) • increase the angle of incidence in 10 degree intervals • from an angle of incidence of 10 degrees to an angle of incidence of 70 degrees. allow use of optical pins instead of a ray box			

4.6.2.2 Properties of electromagnetic waves 1

Answer 16 · Mark scheme

03.4	$\frac{(28 + 25 + 22)}{3} = 25$ 3 (degrees)	 allow alternative method 28 – 22 = 6 (1) = 3 (degrees) (1)	1 1	AO3 4.6.1.3
03.5	Velocity		1	AO1 4.6.2.2
Total			**13**	

4.6.2.2 Properties of electromagnetic waves 1

Answer 17 · Mark scheme

June 2022 | 8463/2HR | Original Q2

Question 2

Question	Answers	Mark	AO / Spec. Ref.
02.1	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 4.6.1.3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content Some indicative content could be indicated within a labelled diagram • place a glass block on a piece of paper • draw around the glass block • use the ray box to shine a ray of light through the glass block • mark the ray of light entering the glass block • mark the ray of light emerging from the glass block • join the points to show the path of the complete ray through the block • and draw a normal line at 90 degrees to the surface • use a protractor to measure the angle of incidence • use a protractor to measure the angle of refraction • use a ray box to shine a ray of light at a range of different angles (of incidence) • increase the angle of incidence in 10 degree intervals • from an angle of incidence of 10 degrees to an angle of incidence of 80 degrees Methods involving mirrors and reflection score zero		

4.6.2.2 Properties of electromagnetic waves 1

Answer 17 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	angle of incidence in degrees / ° on *x*-axis **and** angle of refraction in degrees / ° on *y*-axis		1	AO2 4.6.1.3
	all points plotted correctly	allow **1** mark if 3 or 4 points plotted correctly allow tolerance of half a small square	2	
	curved line of best fit	allow line of best fit from their incorrectly plotted points	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	normal drawn at 90° at the point where the incident ray strikes the mirror		1	AO2 4.6.1.3
	straight line drawn with a ruler **and** angle of incidence = angle of reflection	ignore any arrows	1	

4.6.2.2 Properties of electromagnetic waves 1

Answer 17 · Mark scheme

June 2022 | 8463/2HR | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	(the protractor drawn on the paper means you) do not have to move the mirror (to measure the angles)	allow do not have to mark the position of the rays of light allow protractor does not need to be repositioned	1	AO3 4.6.1.3
	(so) more likely to record the correct angle of incidence and / or reflection	allow reducing random error allow more accurate	1	
	ray in method A does not diverge	allow ray in method A is thin(ner)	1	
	(making it) easier to judge the centre (position) of the ray	allow more accurate if not already awarded allow converse answers in terms of method B being worse than method A	1	

Total Question 2		16

4.6.2.2 Properties of electromagnetic waves 1

Answer 18 · Mark scheme

June 2023 | 8463/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	specular (reflection)		1	AO1 4.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	the angle of incidence = the (mean) angle of reflection		1	AO3 4.6.1.3 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	random any **one** from: • the student's eye / head might not be in the same position each time • the centre of the ray may not have been marked correctly • the mirror / ray box may not have been (re)placed correctly	 allow parallax allow protractor not in the correct position incorrect measurement of the angle(s) is insufficient	1 1	AO3 4.6.1.3 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	all points on a wavefront enter the glass at the same time	allow incident ray (of light) is along the normal	1	AO1 4.6.1.3 RPA9

4.6.2.2 Properties of electromagnetic waves 1

Answer 18 · Mark scheme

June 2023 | 8463/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	the resolution (of the protractor) is 1(°)		1	AO3 4.6.1.3 RPA9
	(so) could not be used to measure the difference between the results	allow (so) could not be used to measure to 1 decimal place	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	different parts of the wavefront enter the glass at different times		1	AO1 4.6.2.2
	the velocity / speed (of light) is less in glass		1	
	(so) one part of the wave front changes speed before other parts		1	

Total Question 7	10

4.6.2.2 Properties of electromagnetic waves 1

Answer 19 · Mark scheme

June 2024 | 8463/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	1 (°)		1	AO3 4.6.1.3 RPA9

Question	Answers	Mark	AO / Spec. Ref.
01.2	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 4.6.1.3 RPA9
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content Some indicative content could be indicated within a labelled diagram • place a glass block on a piece of paper • draw around the glass block • use the ray box to shine a ray of light through the glass block • mark the ray of light entering the glass block • mark the ray of light emerging from the glass block • join the points to show the path of the complete ray through the block • and draw a normal line at 90 degrees to the surface • use a protractor to measure the angle of incidence • use a protractor to measure the angle of refraction • use a ray box to shine a ray of light at a range of different angles (of incidence) • increase the angle of incidence in 10 degree intervals • from an angle of incidence of 10 degrees to an angle of incidence of 60 degrees Methods involving mirrors **and** reflection score zero		

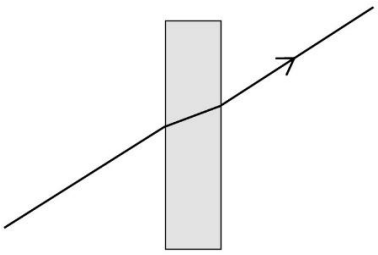
4.6.2.2 Properties of electromagnetic waves 1

Answer 19 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	points plotted correctly curve drawn passing through points	allow tolerance of ± half a small square allow a line starting at the origin	1 1	AO2 4.6.1.3 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	the line curves	allow the line is not straight allow line does not pass through the origin if consistent with their answer to question **01.3**	1	AO3 4.6.1.3 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	normal drawn ray reflected so $i = r$	 judge by eye	1 1	AO2 4.6.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6			1	AO1 4.6.2.2

Total Question 1	**13**

4.6.2.2 Properties of electromagnetic waves 1

Answer 14 · Examiner comments

June 2018 | 8463/2H | Original Q9

Question 9 (Standard/high and High demand)

09.1 Nearly 80% of the students chose the correct description for a model.

09.2 This part was not answered well. Some students appeared to answer the question 'why do scientists use models?'.

09.3 Most students scored either one or two marks. The idea of new evidence or data was often expressed although not always very clearly. When giving an example many students did describe a model and what replaced it but a significant number only mentioned one of the models.

09.4 Nearly 80% of the students scored zero on this question. Some students were aware that the waves changed speed but did not state what the change was. There were many answers in terms of the refraction of light at a boundary and references to water having different density depending on its depth.

09.5 80% of students scored zero. Many answers were simply descriptions of Figure 17.
A common error was to state that the wavefronts did not cross the boundary.

Answer 15 · Examiner comments

June 2019 | 8463/2H | Original Q1

Question 1 (Standard demand)

01.1 Less than half of the students were able to the distance as the focal length.

01.2 Nearly half of the students showed themselves to be familiar with drawing ray diagrams and scored both marks. Most correctly drew one line and usually chose to draw a line passing through the centre of the lens without deviation. A significant number of those students that drew a second line did so incorrectly. About 20% of the students that drew a line correctly did not go on to draw an arrow to show the position and inverted nature of the image.

01.3 About 50% of the students scored zero, most of these simply described similarities or differences in the diagrams eg 'ray goes through centre of both lenses'. Students were not always confident in the use of the term 'virtual' to describe an image and instead wrote 'not real'. A number of answers simply referred to Figure 1 or Figure 2 rather than the type of lens.

01.4 Almost 90% of the students were able to complete the calculation and obtain the correct answer. The most popular wrong answer was '9 x 6 = 54'

4.6.2.2 Properties of electromagnetic waves 1

Answer 16 · Examiner comments — November 2020 | 8463/2H | Original Q3

Question 3 (Standard demand)

03.1 Slightly over 78% of students missed the point of the question, that with a wider ray it would be more difficult to determine the centre of the ray. Many of the students simply repeated, albeit in slightly different words the stem of the question.

03.2 Those students scoring zero generally either failed to draw a line of best fit or failed to extrapolate it. This then gave an answer outside of the permitted range. 30% of students scored both marks.

03.3 There were few complete answers given. Some of the students gave a good practical description but failed to finish the description by including obtaining the range of results given in the table. A small minority of the students described an investigation into reflection rather than refraction

03.4 Just over 55% of students were able to estimate the uncertainty.

03.5 61% of students identified the property of the light wave.

Answer 18 · Examiner comments — June 2023 | 8463/2H | Original Q7

wavelength than that emitted by the Sun.

07.1

28% of students were able to identify this as specular reflection.

07.2

64% of students gave the correct conclusion regarding the angle of incidence and the angle of reflection. There were a number of students who did not analyse the data in detail and failed to consider the magnitude of the angles. These students looked only for a trend and gave increasing angle of incidence resulted in an increase in the angle of reflection, or similar, as their conclusion.

07.3

11% of students gained both marks. Some students are not aware that 'human error' is not an acceptable answer. Others are unable to classify errors correctly. Many responses identifying the cause of the error were not consistent with the error given. Misreading the protractor was a common, but insufficient response.

4.6.2.2 Properties of electromagnetic waves 1

Answer 18 · Examiner comments

June 2023 | 8463/2H | Original Q7

07.4

36% of students gained this mark. Responses often referred to irrelevant factors, such asdensity, transparency of glass and the thickness of the block. 'Not hitting at an angle' was a popular response and a significant number of students seemed to have an idea of the reason but were unable to express themselves with clarity.

07.5

11% of students scored both marks. A significant number of students thought that the results were for angles of reflection, not refraction. There were many students who considered the construction of the protractor and offered various reasons for there being issues with the results.

07.6

8% of students scored all 3 marks on this question. Very few answers recognised the significance of parts of the wavefront reaching the boundary at different times and hence changing speed at different times. Students, generally, only gained credit for appreciating that the velocity/speed of light was less in glass than in air and these students were in a minority. Some students were aware that change in speed was involved but were unable to put together a coherent argument that matched the second marking point. There were many simplistic answers that referred to variation in optical density and light rays rather than wavefronts.

4.6.2.2 Properties of electromagnetic waves 1

Answer 19 · Examiner comments June 2024 | 8463/2H | Original Q1

01.1
69% of students correctly gave the resolution of the protractor. Answers of 10, 90 and 180 degrees were frequently seen.

01.2
Answers to this level of response question about the refraction of light included details, such as drawing round the block, that suggested that most students were familiar with this practical. Most students were aware of the need to incorporate the drawing of a normal into their account and described the need to measure the angles of incidence and refraction. Many students, however, described a method that would not necessarily lead to a valid outcome because they did not clearly identify the location of the angles or describe a method to mark the path of the ray of light through the glass block. Most students failed to describe the range and interval of angle of incidence that should be used to obtain the results recorded in the table reproduced in the question. A small number had not read the question carefully and described reflection at a mirror. 38% of responses were level 2 and16% level 3.

01.3
Very few errors were made in the plotting of the 2 points on the graph of angle of incidence against angle of refraction, but many students drew a straight line of best fit. This is connected to the misconception that a line of best fit is always straight.

01.4
74% of students were able to answer this question about the relationship in the graph correctly. Of those who drew a straight line of best fit in **01.3**, a large number described the points as not lying on the line of best fit.

01.5
Students did not always take sufficient care in drawing the reflected ray to show that i = r. A significant number of students appeared to have only read the first part of the question and, consequently, had not drawn a normal. 61% scored both marks, 21% scored one.

01.6
73% of students identified the correct ray diagram for refraction of light.