

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

- 1 (a) Figure 1 shows how the visible spectrum of white light is shown on a screen.

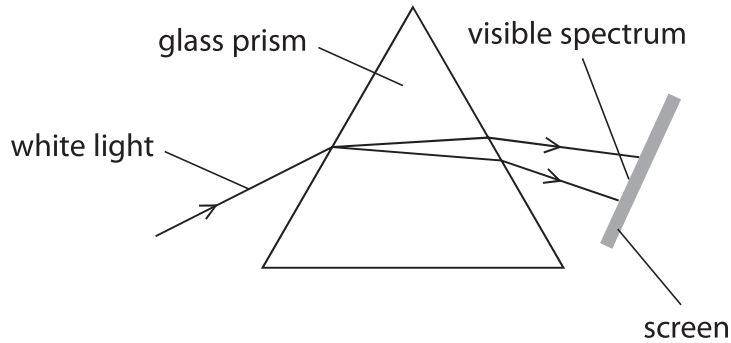


Figure 1

- (i) Which of these is the best piece of equipment to produce the white light? (1)

- ☐ **A** ray box
- ☐ **B** ruler
- ☐ **C** measuring cylinder
- ☐ **D** ammeter

- (ii) Which colour is seen between yellow and blue in the spectrum on the screen? (1)

- ☐ **A** red
- ☐ **B** orange
- ☐ **C** green
- ☐ **D** violet



(b) Figure 2 shows the main parts of the electromagnetic spectrum.

radio	microwaves	infrared	visible light	ultraviolet	x-rays	gamma rays
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Figure 2

Complete the following sentences using information from Figure 2. Each part of the electromagnetic spectrum may be used once, more than once or not at all.

(i) The part of the electromagnetic spectrum used to detect broken bones is (1)

.....

(ii) The part of the electromagnetic spectrum used in thermal imaging is (1)

.....

(iii) The part of the electromagnetic spectrum that
• is used to cook food
AND
• has a shorter wavelength than microwaves is (1)

.....

(iv) The part of the electromagnetic spectrum that
• is used to sterilise medical equipment
AND
• has a shorter wavelength than x-rays is (1)

.....

(Total for Question 1 = 6 marks)

2 This question is about waves.

(a) Figure 3 is a diagram of a **water wave** in a ripple tank.

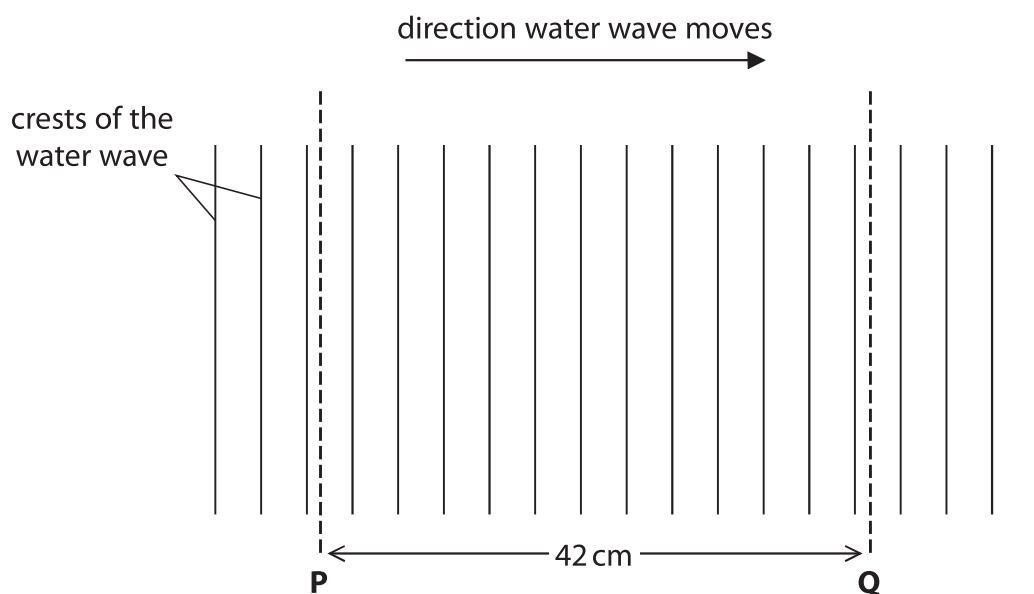


Figure 3

(i) State the number of crests of the wave between **P** and **Q**.

(1)

number of crests =

(ii) The distance between **P** and **Q** is 42 cm.

Calculate the wavelength of the water wave in Figure 3.

(2)

wavelength = cm



(iii) Describe how a student could determine the wave speed of the water wave in Figure 3.

(3)

.....

.....

.....

.....

.....

.....

(b) (i) Which row of the table is correct for **sound waves**?

(1)

		sound waves are	can sound waves transfer energy?
☐	A	longitudinal	yes
☐	B	longitudinal	no
☐	C	transverse	yes
☐	D	transverse	no

(ii) A sound wave has a frequency of 440 Hz and a wavelength of 0.75 m.

Calculate the wave speed of the sound wave.

(2)

wave speed = m/s

(Total for Question 2 = 9 marks)

.....

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



3 This question is about reflection and refraction of light.

(a) (i) Figure 4 shows a ray of light travelling to a plane mirror.

On Figure 4, draw the ray of light after it **reflects** off the mirror surface.

(2)

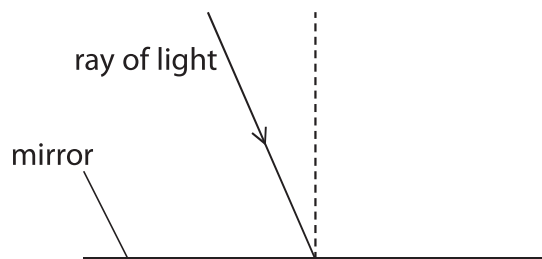


Figure 4

(ii) Figure 5 shows a ray of light in air travelling to a glass block.

On Figure 5, draw the ray of light after it **refracts** at the surface of the glass block.

(2)

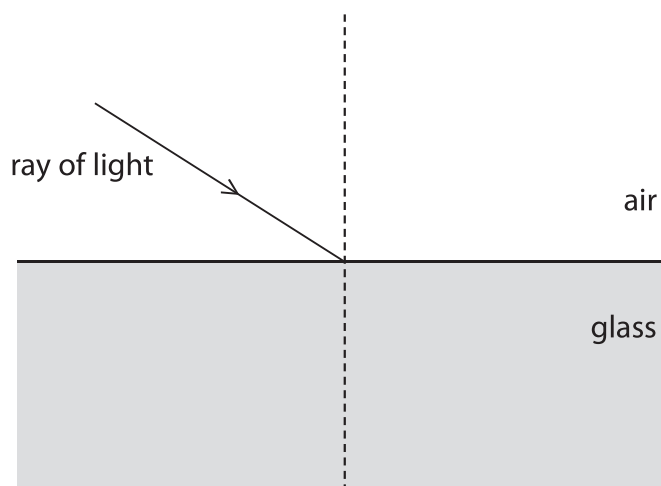


Figure 5

(iii) Figure 6 shows a ray of light in water, travelling to the surface of the water.

The angle marked **X** is greater than the critical angle.

On Figure 6, draw the ray of light after it reaches the surface of the water.

(2)

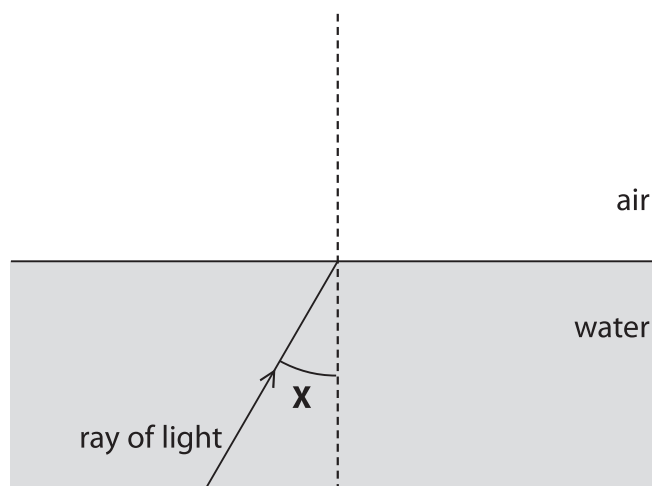


Figure 6

(b) A converging lens has a focal length of 40 cm.

Calculate the power of this lens in dioptries.

Use the equation

$$\text{power in dioptries} = \frac{1}{\text{focal length in metres}}$$

(3)

power of the lens = dioptries

(Total for Question 3 = 9 marks)



2 (a) Figure 1 shows the parts of the electromagnetic spectrum.

gamma rays	x-rays	J	visible	K	micro-waves	L
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Figure 1

(i) Which row of the table names the parts **J**, **K** and **L** of the electromagnetic spectrum? (1)

	J	K	L
☐ A	infrared	radio	ultraviolet
☐ B	radio	infrared	ultraviolet
☐ C	ultraviolet	infrared	radio
☐ D	ultraviolet	radio	infrared

(ii) All electromagnetic waves can travel in a vacuum.

Which of these is the same for all electromagnetic waves travelling in a vacuum? (1)

- ☐ **A** amplitude
- ☐ **B** frequency
- ☐ **C** speed
- ☐ **D** wavelength

(b) X-rays can be useful and harmful to humans.

(i) State **one** way that x-rays are useful to humans. (1)

(ii) State **one** way that x-rays are harmful to humans. (1)



- (c) A person warms their hands in front of a hot fire as shown in Figure 2.



(Source: © Andreas Saldavs/Shutterstock)

Figure 2

Use words from the box to complete the following sentences.

chemical infrared radio thermal ultraviolet

(2)

The electromagnetic waves that the fire mostly emits are waves.

These waves transfer energy to the hands.

(Total for Question 2 = 6 marks)

7 This question is about light.

(a) White light includes all the colours in the visible spectrum.

A beam of white light is the only light that shines on a book.

The book appears green.

A red filter is placed between the source of white light and the book.

What colour does the book appear now?

(1)

- ☐ **A** black
- ☐ **B** blue
- ☐ **C** green
- ☐ **D** red

(b) Figure 8 shows a shiny metal ball.



(Source: © frerd/Shutterstock)

Figure 8

A clear image of a building can be seen on the surface of the ball.

(i) This clear image is an example of

(1)

- ☐ **A** diffuse reflection
- ☐ **B** diffuse refraction
- ☐ **C** specular reflection
- ☐ **D** specular refraction



- (ii) Explain why the surface of the metal ball gives a **clear** image.
You may draw diagrams to help with your answer.

(2)

- (c) Figure 9a and Figure 9b show rays of light before and after passing through different lenses.

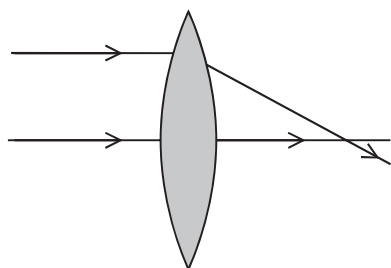


Figure 9a

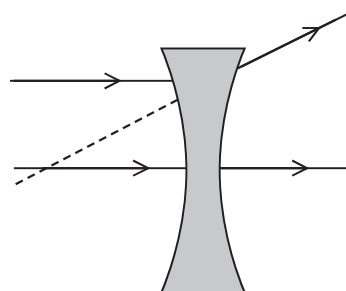


Figure 9b

- (i) State **one** similarity and **one** difference in the way the rays of light pass through the lenses.

(2)

similarity.....

difference.....



(ii) Figure 10 shows two glass lenses P and Q.

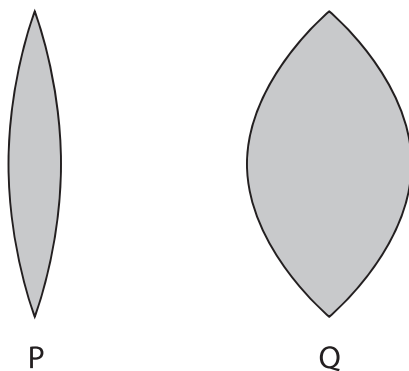


Figure 10

State how the power of P is different from the power of Q.

(1)

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



- * (d) Figure 11a shows refraction of light at a boundary between glass and air.
Figure 11b shows total internal reflection of light at a boundary between glass and air.

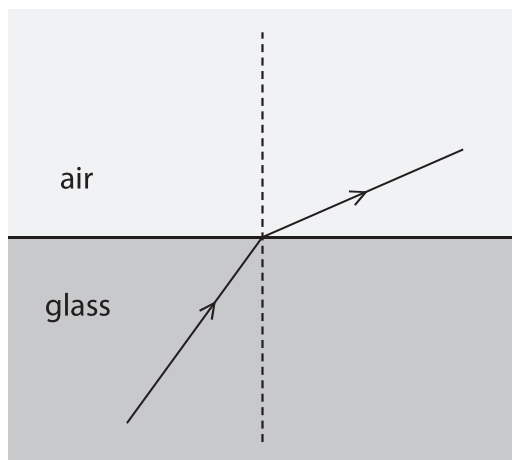


Figure 11a

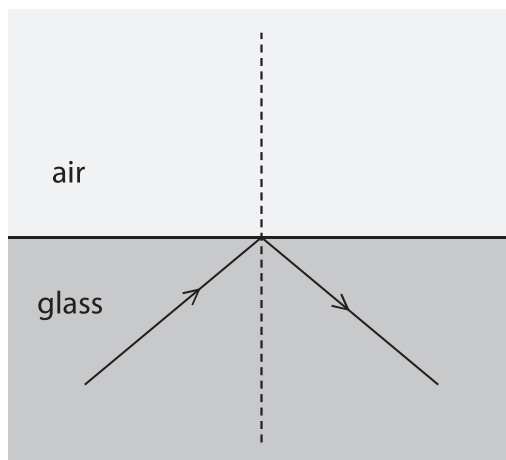


Figure 11b

Use Figure 11a and Figure 11b to explain refraction and total internal reflection.

You may add to Figure 11a and Figure 11b to help with your answer.

(6)

(Total for Question 7 = 13 marks)



- 8 (a) Figure 12 shows part of a wave.

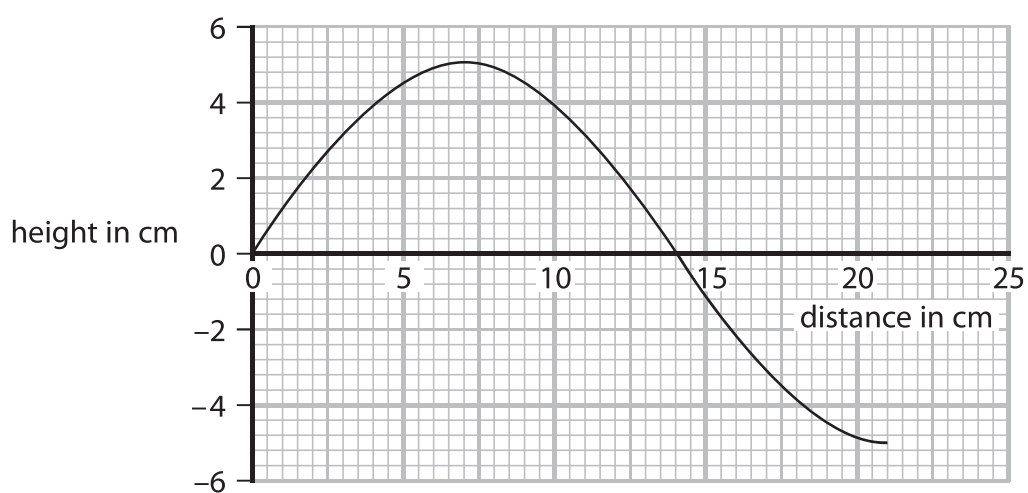


Figure 12

Use data from Figure 12 to calculate the wavelength of the wave.

(2)

wavelength = cm



- (b) (i) Figure 13 shows a student sitting on the shore of a lake watching ripples on the surface of the water moving past a toy boat.

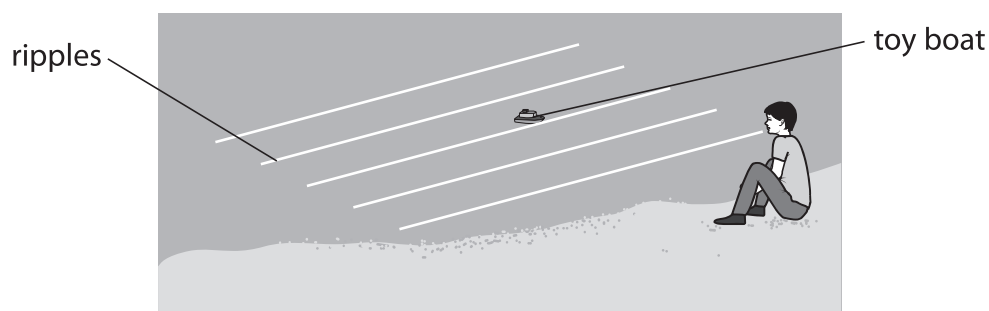


Figure 13

The student has a stopwatch.

Describe how the student could determine the frequency of the ripples on the lake.

(3)

- (ii) The speed of a water wave is 1.5 m/s.

The frequency of the wave is 0.70 Hz.

Calculate the wavelength of this wave.

Use the equation

$$v = f \times \lambda$$

(2)

wavelength = m



(iii) Water waves are transverse waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

(c) Sound waves travel at 330 m/s in air.

A student sees a flash of lightning.

The student hears the sound of thunder 4.0 s later.

Calculate the distance from the student to the flash of lightning.

Use the equation

$$x = v \times t$$

(2)

distance = m

(Total for Question 8 = 11 marks)



Question Number	Answer	Mark
1(a)(i)	A ray box <i>B is not correct because a ruler does not produce a beam of white light</i> <i>C is not correct because a measuring cylinder does not produce a beam of white light</i> <i>D is not correct because an ammeter does not produce a beam of white light</i>	(1) AO1

Question Number	Answer	Mark
1(a)(ii)	C green <i>A is not correct because red appears at the start of the spectrum</i> <i>B is not correct because orange appears in the middle of the spectrum</i> <i>D is not correct because violet appears at the end of the spectrum</i>	(1) AO1

	Answer	Additional guidance	Mark
1(b)(i)	x-ray(s)	allow X x no mark if more than one wave given e.g. x-rays and gamma rays scores 0	(1) AO1

	Answer	Additional guidance	Mark
1(b)(ii)	infrared	allow any recognisable spelling IR ir no mark if more than one wave given e.g. infrared and gamma rays scores 0	(1) AO1

	Answer	Additional guidance	Mark
1(b)(iii)	infrared	allow any recognisable spelling IR ir no mark if more than one wave given e.g. infrared and gamma rays scores 0	(1) AO1

	Answer	Additional guidance	Mark
1(b)(iv)	gamma (rays)	allow any recognisable spelling γ no mark if more than one wave given e.g. gamma rays and UV scores 0	(1) AO1

(Total for Question 1= 6 marks)

	Answer	Additional guidance	Mark
2(a)(i)	12		(1) AO1

	Answer	Additional guidance	Mark
2(a)(ii)	$\frac{42}{12}$ (1) 3.5(cm) (1)	ecf from 2ai allow 0.035 for 1 mark award full marks for the correct answer without working	(2) AO1

	Answer	Additional guidance	Mark
2(a)(iii)	A description to include: either time a crest/ripple/wavefront (1) (moving) between P and Q (1) use (wave speed =) $\frac{\text{distance}}{\text{time}}$ (1) or count number of crests /ripples /wavefronts passing (eg P) (1) in a given time (to find f) (1) use ($v = f \lambda$) (1)	allow 'how long it takes' allow 'wave' for crest allow – over the 42 cm over a (set) distance allow waves if no other mark scored measure frequency for 1 mark	(3) AO1

Question Number	Answer	Mark
2(b)(i)	A longitudinal yes B is not correct because sound waves can transfer energy C is not correct because sound waves are longitudinal D is not correct because sound waves are longitudinal and sound waves can transfer energy	(1) AO1

	Answer	Additional guidance	Mark
2(b)(ii)	select wave equation (1) $(v =) f \times \lambda$ evaluation (1) (speed =) 330 (m/s)	(speed =) freq(uency) $\times$ wavelength (speed =) 440×0.75 award full marks for the correct answer without working.	(2) AO2

(Total for Question 2 = 9 marks)

	Answer	Additional guidance	Mark
3(a)(i)	diagram to include: a reflected ray drawn (1) angle of reflection = angle of incidence (1)	judge by eye	(2) AO2

	Answer	Additional guidance	Mark
3(a)(ii)	diagram to include: a refracted ray drawn (1) angle of refraction < angle of incidence (1)	Ray drawn in bottom right quadrant of diagram ignore reflected rays judge by eye	(2) AO2

	Answer	Additional guidance	Mark
3(a)(iii)	diagram to include: ray drawn showing total internal reflection (1) angle of reflection = angle of incidence (1)	REJECT any refracted ray for this mark judge by eye	(2) AO2

	Answer	Additional guidance	Mark
3(b)	substitution (1) evaluation without correct unit change (1) evaluation including unit change (1) 2.5 (dioptries)	(power) = $\frac{1}{0.40}$ allow 4 to any power of 10 in the substitution allow 2.5 to any power of 10 (dioptries) 2.5 to any other power of 10 scores 2 marks award full marks for the correct answer without working	(3) AO2

(Total for Question 3 = 9 marks)

Question number	Answer	Additional guidance	Mark			
2a(i)	C <table><tr><td>ultraviolet</td><td>infrared</td><td>radio</td></tr></table> A is incorrect infrared should be in K, radio should be in L and ultraviolet in J, B is incorrect radio should be in L and ultraviolet should be in K D is incorrect radio should be in L and infrared in K	ultraviolet	infrared	radio		(1) AO1
ultraviolet	infrared	radio				

Question number	Answer	Additional guidance	Mark
2a (ii)	C speed amplitude, frequency and wavelength are not the same for all EM waves		(1) AO1

Question number	Answer	Additional guidance	Mark
2(b) (i)	One from: seeing (broken) bones (1) radiotherapy (1) detecting cracks in metals (1) airport security (1) observing the internal structure of objects(1)	seeing inside the body	(1) AO1

Question number	Answer	Additional guidance	Mark
2(b) (ii)	One from: can cause cancer (1) can cause burns(1) {damage/kills/harms} cells/tissue (1) mutates DNA/cells (1)	harms organ(s) / fetus allow (highly) ionising	(1) A01

Question number	Answer	Additional guidance	Mark
2(c)	infrared (1) thermal (1)	must be in first sentence space must be in second sentence space award 2 marks for answers in this order	(2) A02

Total marks for question 2=6 marks

Question number	Answer	Mark
7(a)	A black B is incorrect as no blue light shines on the object C is incorrect as no green light shines on the object D is incorrect as no red light is reflected from the object	(1) A03

Question number	Answer	Additional guidance	Mark
7 (b)(i)	C specular reflection A is incorrect as the reflection is not diffuse B is incorrect as it is not refraction D is incorrect as it is not refraction		(1) A01

Question number	Answer	Additional guidance	Mark
7 (b)(ii)	An explanation linking: (the surface/metal ball) is smooth/shiny (1) (for each ray of light) the angle of incidence is equal to the angle of reflection (1)	like a mirror the reflection is even / there is no scattering full marks can be awarded for labelled diagrams	(2) A02

Question number	Answer	Additional guidance	Mark
7 c(i)	similarity (both) change direction /bend/refract (rays of light) (1) OR (rays of light/they) pass/go (straight) through the (optical) centre / focus(1) difference one converges the other diverges (1)	accept ray through centre described as 'bottom ray' accept 'top ray' accept refracts/bends in different ways do not allow 'change in direction of top ray' this is a similarity	(2) AO3

Question number	Answer	Additional guidance	Mark
7c(ii)	(the power of) P is less than (the power of) Q	ORA allow Q is greater /bigger	(1) AO2

Question number	Indicative content	Mark
7d*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Refraction • Angle of incidence marked • Angle of refraction marked • Angles are measured from the normal • Angle of refraction is bigger than the angle of incidence • Rays of light travel in straight lines • Refraction occurs at a boundary between two materials of different (optical) density • The angle of incidence is less than the angle of refraction when light passes into a less dense medium (glass into air) • Refraction is a change in direction of a light ray. • Refracted rays bend away from the normal when light passes into a less dense medium (glass into air) • The ray in the more dense medium (glass) travels more slowly ORA Total Internal Reflection • Possible critical angle marked • Light stays inside the glass • Only occurs when the incident light is in the more dense medium • Only occurs when the incident angle is equal to greater than the critical angle • Critical angle for glass is about 42° • Angle of incidence is equal to the angle of reflection	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about refraction or total internal reflection(TIR)	<u>Possible candidate responses</u> naming of any rays of light or any angles in text or on diagrams light changes direction/bends TIR ray stays inside the glass / does not go into air refracted ray goes through glass and air
Level 2	3–4	<u>Additional guidance</u> simple description of refraction and TIR or facts about one and more detail of the other	<u>Possible candidate responses</u> Angle or ray identified For refraction light changes direction from glass into air or TIR angles are equal inside the glass
Level 3	5–6	<u>Additional guidance</u> detailed description of refraction and TIR	<u>Possible candidate responses</u> For refraction light changes direction from glass into air AND TIR angles are equal inside the glass

Total marks for question 7 =13

Question number	Answer	Additional guidance	Mark
8(a)	uses data taken from x axis (1) 28(cm) (1)	award full marks for correct answer without working	(2) A03

Question number	Answer	Additional guidance	Mark
8 b(i)	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = $\frac{\text{number of waves}}{\text{time}}$ (1)	ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	(3) A01

Question number	Answer	Additional guidance	Mark
8 b(ii)	substitution (1) $1.5 = 0.7 \times \lambda$ rearrangement and evaluation 2.1(4) m	$\frac{1.5}{0.7}$ allow $\frac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. $\lambda = v/f$ scores 1 mark	(2) AO2

Question number	Answer	Additional guidance	Mark
8 b(iii)	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal – (oscillations) in same direction as wave (travel) (1)	up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	(2) AO1

Question number	Answer	Additional guidance	Mark
8 (c)	substitution $(x) = 330 \times 4.0$ evaluation 1300 (m)	accept 1320 (m) award full marks for correct answer without working.	(2) AO2

Total marks for Question 8 = 11

If you're taking **GCSE (9–1) Combined Science** or **GCSE (9–1) Physics**, you will need these equations:

HT = higher tier

distance travelled = average speed × time	
acceleration = change in velocity ÷ time taken	$a = \frac{(v - u)}{t}$
force = mass × acceleration	$F = m \times a$
weight = mass × gravitational field strength	$W = m \times g$
HT momentum = mass × velocity	$p = m \times v$
change in gravitational potential energy = mass × gravitational field strength × change in vertical height	$\Delta GPE = m \times g \times \Delta h$
kinetic energy = $\frac{1}{2} \times \text{mass} \times (\text{speed})^2$	$KE = \frac{1}{2} \times m \times v^2$
efficiency = $\frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	
wave speed = frequency × wavelength	$v = f \times \lambda$
wave speed = distance ÷ time	$v = \frac{x}{t}$
work done = force × distance moved in the direction of the force	$E = F \times d$
power = work done ÷ time taken	$P = \frac{E}{t}$
energy transferred = charge moved × potential difference	$E = Q \times V$
charge = current × time	$Q = I \times t$
potential difference = current × resistance	$V = I \times R$
power = energy transferred ÷ time taken	$P = \frac{E}{t}$
electrical power = current × potential difference	$P = I \times V$
electrical power = (current) ² × resistance	$P = I^2 \times R$
density = mass ÷ volume	$\rho = \frac{m}{V}$

	force exerted on a spring = spring constant $\times$ extension	$F = k \times x$
	(final velocity) ² – (initial velocity) ² = 2 $\times$ acceleration $\times$ distance	$v^2 - u^2 = 2 \times a \times x$
HT	force = change in momentum $\div$ time	$F = \frac{(mv - mu)}{t}$
	energy transferred = current $\times$ potential difference $\times$ time	$E = I \times V \times t$
HT	force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density $\times$ current $\times$ length	$F = B \times I \times l$
	For transformers with 100% efficiency, potential difference across primary coil $\times$ current in primary coil = potential difference across secondary coil $\times$ current in secondary coil	$V_p \times I_p = V_s \times I_s$
	change in thermal energy = mass $\times$ specific heat capacity $\times$ change in temperature	$\Delta Q = m \times c \times \Delta\theta$
	thermal energy for a change of state = mass $\times$ specific latent heat	$Q = m \times L$
	energy transferred in stretching = 0.5 $\times$ spring constant $\times$ (extension) ²	$E = \frac{1}{2} \times k \times x^2$

If you're taking **GCSE (9–1) Physics**, you also need these extra equations:

	moment of a force = force $\times$ distance normal to the direction of the force	
	pressure = force normal to surface $\div$ area of surface	$P = \frac{F}{A}$
HT	$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
	to calculate pressure or volume for gases of fixed mass at constant temperature	$P_1 \times V_1 = P_2 \times V_2$
HT	pressure due to a column of liquid = height of column $\times$ density of liquid $\times$ gravitational field strength	$P = h \times \rho \times g$

END OF EQUATION LIST