AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.6.1.1

Transverse and longitudinal waves

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**6**
Available paper years	**2018–2025**

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.

6.6.1.1 Transverse and longitudinal waves

Answer 01 · Mark scheme June 2018 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	in a longitudinal wave, the oscillations / vibrations are parallel to the direction of energy transfer	allow direction of travel for energy transfer	1	AO1 6.6.1.1
	in a transverse wave, the oscillations / vibrations are perpendicular to the direction of energy transfer	allow direction of travel for energy transfer if no other mark scored allow **1** mark for (oscillations / vibrations of) longitudinal waves are parallel **and** (oscillations / vibrations of) transverse waves are perpendicular if no other mark scored allow **1** mark for transverse waves have peaks and troughs **and** longitudinal waves have compressions and rarefactions	1	
05.2		an answer of 0.063 (m) scores **3** marks		AO2 6.6.1.2
	$3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$	allow $\lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$ this mark may be awarded if the standard form values are incorrectly converted	1	
	$\lambda = 0.0625$ (m)		1	
	$\lambda = 0.063$ (m) **or** $\lambda = 6.3 \times 10^{-2}$ (m)	allow an answer to 2 sig figs that is consistent with their calculated value of λ and has required rounding	1	

6.6.1.1 Transverse and longitudinal waves

Answer 01 · Mark scheme

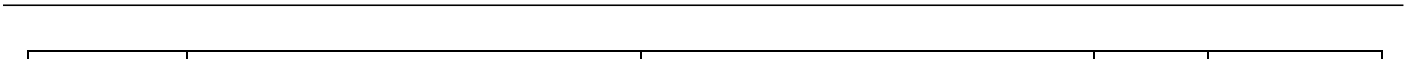
June 2018 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	any **three** from: • (the car aerial) absorbs radio waves or energy • electrons are made to vibrate (in the aerial) • creating an alternating current (in the aerial circuit) • the (signal) frequency is the same (as the radio wave)		3	AO1 6.6.2.3
Total			**8**	

6.6.1.1 Transverse and longitudinal waves

Answer 01 · Mark scheme

June 2018 | 8464/P/2H | Original Q5



6.6.1.1 Transverse and longitudinal waves

Answer 02 · Mark scheme

Question	Answers	Mark	AO / Spec. Ref.	ID
02.1	**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 6.6.1.2	E
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan 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 • If two quantities have been determined, v = f λ can be used to find the third. **Frequency** • use a stopclock • count the number of waves passing a point in a fixed time period • divide the time by the number of waves to determine the time for one wave, T • f = 1/T • read the frequency off the oscillator **Wavelength** • use a camera to freeze the image • use a metre rule to measure the distance between two wavefronts • count the number of waves between the wavefronts • divide distance by the number of waves to determine λ **Velocity** • determine a mean value of frequency • determine a mean value of wavelength • measure the time it takes one wavefront to travel the length of the screen • measure the length of the screen • speed = distance / time to access Level 3 there must be a description of how frequency, wavelength and velocity can be determined			

6.6.1.1 Transverse and longitudinal waves

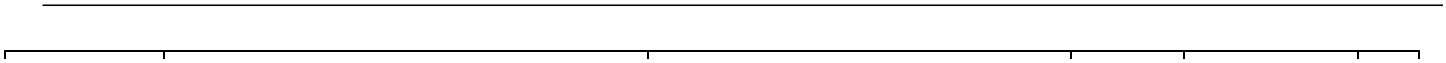
Answer 02 · Mark scheme

02.2	(the duck) moves perpendicular to the direction of wave travel	duck moves up and down is insufficient	1	AO2 6.6.1.1	E
02.3	mean maximum height = 511 **and** mean minimum height = 500 511 – 500 = 11 11 / 2 = 5.5 (mm)	an answer of 5.5 gains **3** (mm) marks allow a calculated difference from incorrect means allow their difference divided by 2 any correct method of determining the mean amplitude can score **3** marks	1 1 1	AO2 6.6.1.2	E
Total			**10**		

6.6.1.1 Transverse and longitudinal waves

Answer 02 · Mark scheme

June 2019 | 8464/P/2H | Original Q2



6.6.1.1 Transverse and longitudinal waves

Answer 03 · Mark scheme

June 2022 | 8464/P/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	**A** = rarefaction **B** = wavelength		1 1	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	f = 4000 Hz		1	AO2
	$T = \frac{1}{4000}$	allow a correct substitution using an incorrectly / not converted value of f	1	AO2
	T = 0.00025	allow a correct calculation using an incorrectly / not converted value of f	1	AO2
	seconds **or** s		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	wave speed = frequency × wavelength **or** $v = f\lambda$		1	AO1 6.6.1.2

6.6.1.1 Transverse and longitudinal waves

Answer 03 · Mark scheme

June 2022 | 8464/P/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	$v = 348$	allow a value in the range 347 to 348 subsequent marks may only be awarded if value for v is in the range 343 to 349	1	AO2 6.6.1.2
	$348 = 300 \times \lambda$	allow a correct substitution using an incorrect value of v read from graph	1	
	$\lambda = \frac{348}{300}$	allow a correct rearrangement using an incorrect value of v read from graph	1	
	1.16 (m)	allow 1.2 (m) allow a correct calculation using an incorrect value of v read from graph allow a maximum of **2** marks for use of v = 330 m/s	1	

Total Question 1		**11**

Answer 04 · Mark scheme

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	distance across all 8 wavelengths = 113 (mm) their distance × 5.0 wavelength = 70 (mm)	allow a range from 108 (mm) to 118 (mm) allow a range from 68 mm to 72 mm	1 1 1	AO2 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	97 × 5 = (96 + 99 + 97 + **X** + 97) **X** = 96	allow **X** = (97 × 5) – (96 + 99 + 97 + 97)	1 1	AO2 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	the spread of values about the mean is very small		1	AO3 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	the oscillations / vibrations in longitudinal waves are parallel to the direction of energy transfer (whereas) the oscillations / vibrations in transverse waves are perpendicular to the direction of energy transfer	allow direction of wave travel for direction of energy transfer if no other mark awarded allow 1 mark for oscillations / vibrations in longitudinal waves are parallel **and** oscillations / vibrations in transverse waves are perpendicular	1 1	AO1 6.6.1.1

Total Question 3	8

6.6.1.1 Transverse and longitudinal waves

Answer 05 · Mark scheme

June 2024 | 8464/P/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	speed (in a vacuum/air) **or** transfer energy	ignore they can travel through air allow they can be reflected / refracted	1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	oscillations / vibrations are perpendicular to the direction of energy transfer	allow wave travel for energy transfer	1	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	microwaves	allow radio waves	1	AO1 6.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	violet	allow purple	1	AO1 6.6.2.1

6.6.1.1 Transverse and longitudinal waves

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	any **two** from • (ultraviolet and /or X-rays and / or gamma rays) can cause mutations in genes / DNA • ultraviolet can cause skin to age and / or skin cancer • X-rays and / or gamma rays increase the risk of cancers	 allow can damage / kill cells ignore mutations in cells allow ultraviolet can cause sunburn or eye damage allow X-rays and / or gamma rays can cause cancers if no other mark awarded allow **1** mark for (the three highest frequency groups) can cause cancer	2	AO1 6.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	$4.0 \times 10^{-10} = \frac{1}{\text{frequency}}$ $\text{frequency} = \frac{1}{4.0 \times 10^{-10}}$ 2.5×10^{9} (Hz)	 only award if answer is in standard form	1 1 1	AO2 6.6.1.2

6.6.1.1 Transverse and longitudinal waves

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.7	radio waves are produced (by the transmitter)	allow microwaves are produced (by the transmitter)	1	AO1 6.7.2.1
	the detector absorbs the waves / energy		1	
	(which produces) an alternating current	allow causing electrons to oscillate	1	
	with the same frequency as the (transmitted) waves	allow with the same frequency as the oscillations in the transmitter	1	

Total Question 3	13

6.6.1.1 Transverse and longitudinal waves

Answer 06 · Mark scheme

June 2025 | 8464/P/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	oscillations / vibrations are perpendicular to the direction of energy transfer	allow oscillations / vibrations are perpendicular to the direction of wave travel allow **1** mark for oscillations/ vibrations are perpendicular	2	AO1 6.6.1.1

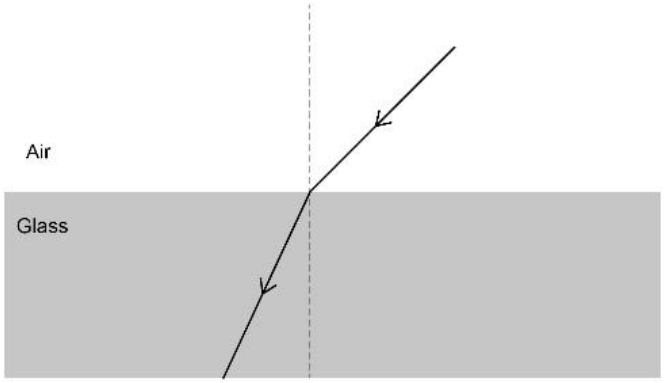
Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	skin cancer **or** causes skin to age (prematurely)	allow skin cell mutation ignore cancer unqualified	1	AO1 6.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	shorter		1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	$3.00 \times 10^{8} = 6.25 \times 10^{14} \times \lambda$ $\lambda = \dfrac{3.00 \times 10^{8}}{6.25 \times 10^{14}}$ $\lambda = 4.80 \times 10^{-7}$ (m) $\lambda = 480$ (nm)	 allow a correct conversion to nm of their incorrectly calculated value of λ using the numbers from the question	1 1 1 1	AO2 6.6.1.2

6.6.1.1 Transverse and longitudinal waves

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	the speed of the light / waves / wavefronts decreases (when entering the lens) (so) one end of the wavefront slows before the other end	allow the speed of light / waves / wavefronts is less in the lens (than in air) ignore lens has a higher density than air ignore references to refractive index	1 1	AO1 6.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	normal line drawn ray drawn with an angle of refraction of 28°  ignore ray below the glass	allow a normal line that only extends from the boundary into the glass	1 1	AO2 6.6.2.2

Total Question 3	12

6.6.1.1 Transverse and longitudinal waves

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q5

Question 5 (standard & standard / high demand)

05.1 Nearly 13% gave accurate answers to score both marks. A further 20% were able to score a compensation mark by vague references to parallel and perpendicular, but it was clear that many students do not realise the importance of what is oscillating and the direction of energy transfer. There were many vague incorrect descriptions of 'up and down' and 'side to side'.

05.2 25% gained full marks, and a further 18% gained two marks, usually not giving the answer to two significant figures. There were a large number of responses using an incorrect rearrangement of the equation and generally the use of standard form was not the cause of the errors.

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q5

05.3 This was very poorly done, with just over 1% gaining full marks. There were many vague responses and a significant number of candidates wrote about transverse and longitudinal waves. There was also considerable reference to radio waves being reflected off the ionosphere.

A significant minority of students did not attempt this question which might suggest that they were unfamiliar with the material.

6.6.1.1 Transverse and longitudinal waves

Answer 03 · Examiner comments — June 2022 | 8464/P/2H | Original Q1

Question 1 (Standard demand)

01.1 Of the 90% of students that scored marks on this question, the majority were able to identify the wavelength for 1 mark. 35% of students also identified the rarefaction to score 2 marks.

01.2 10% of students scored full marks on this question. 25% of students scored 3 marks, the majority of whom did the conversion, but did not give the unit. 50% of students scored 2 marks on this question, failing to do the conversion or recall the unit.

01.3 Over 99% of students were able to select the correct equation.

01.4 The majority of students understood what was required to answer this question. Nearly 65% of students gained full marks. Some students read the correct value from the graph, but then wrote this as their final answer. Some students just multiplied 300 by 28.

Answer 04 · Examiner comments — June 2023 | 8464/P/2H | Original Q3

Question 3 (standard demand and standard/high demand)

03.1 Many students found this question challenging, even though this forms part of a required practical. Approximately 50% of students scored marks, but only a small percentage arcuately measured across a number of wavelengths, and then applied the scale factor correctly and scored full marks. The majority of students that scored one mark measured across one wavelength and multiplied that by 5.

03.2 This calculation was well answered, with 90% of students scoring two marks.

03.3 Only 40% of students knew that for precise readings the spread of values about the mean is very small.

03.4 25% of students scored marks on this question. 15% of students scored two marks. Of the 10% of students who scored one mark, most wrote vague answers stating that longitudinal waves are parallel and transverse waves are perpendicular, but didn't mention oscillations or energy transfer.

6.6.1.1 Transverse and longitudinal waves

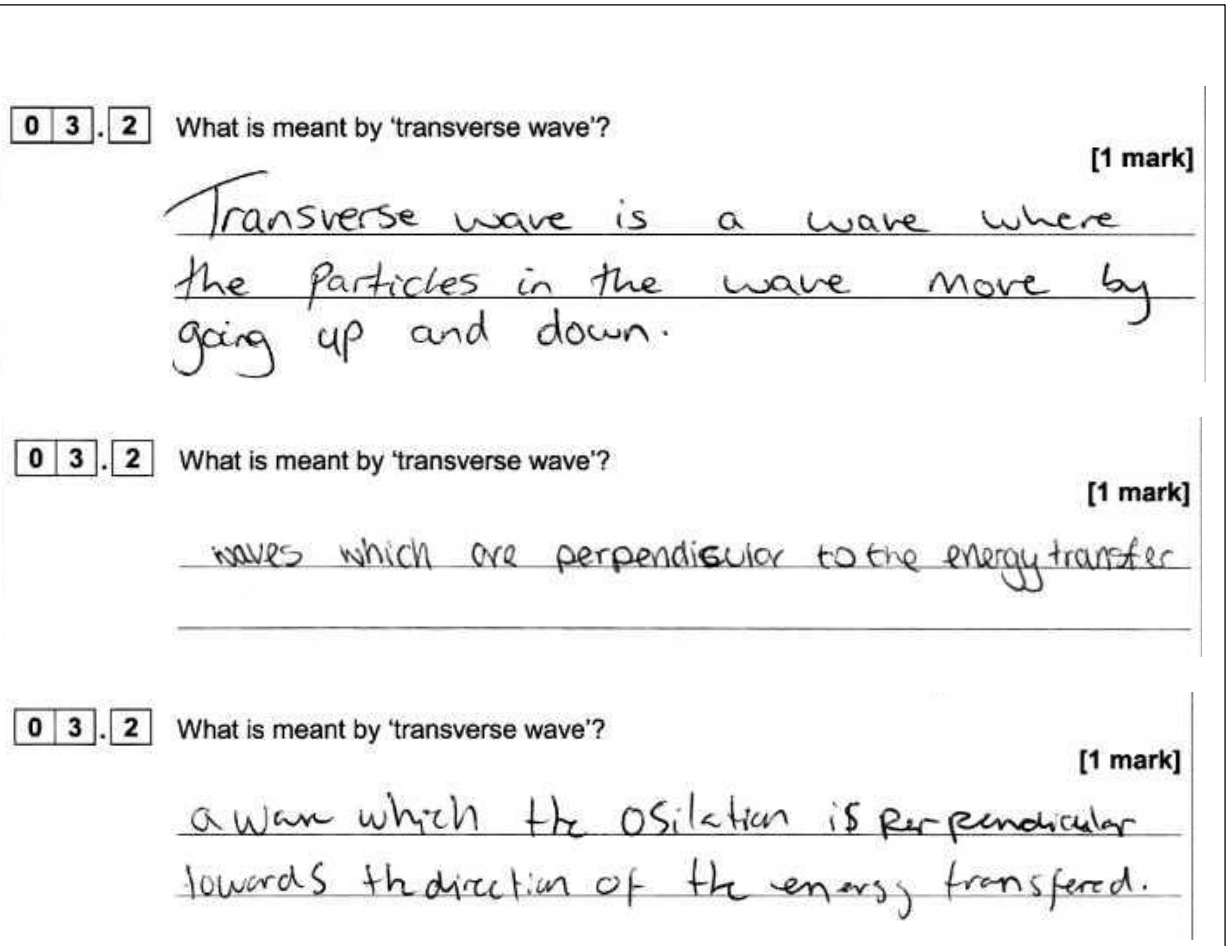
Answer 05 · Examiner comments

June 2024 | 8464/P/2H | Original Q3

Question 3 (standard, standard/high & high demand)

03.1 This question proved to be more demanding than expected, with just over 20% of students able to give a correct property of electromagnetic waves. Many students simply repeated the wording of the stem (that they can travel through a vacuum) even though they were asked of one *other* property. Some students attempted to describe a transverse wave.

03.2 Just over 20% of students were able to describe a transverse wave. Most demonstrated some understanding, but answers were often insufficient or too vague for the mark. When describing transverse waves, it must be clear that oscillations are perpendicular to the direction of energy transfer. Most answers were missing some part of the description.



0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

Transverse wave is a wave where the particles in the wave move by going up and down.

0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

waves which are perpendicular to the energy transfer

0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

a wave which the oscilation is perpendicular towards the direction of the energy transfered.

The first two examples here are not sufficient to gain the marks. In the first, the student demonstrates some understanding but the language is very vague and there is no mention of energy transfer. The second response gives an *almost* complete description but there is no mention of oscillations/vibrations so the mark cannot be awarded.

The third response has all the required aspects of the description so the mark is awarded.

03.3 This AO1 question was well answered with 85% of students giving the correct response.

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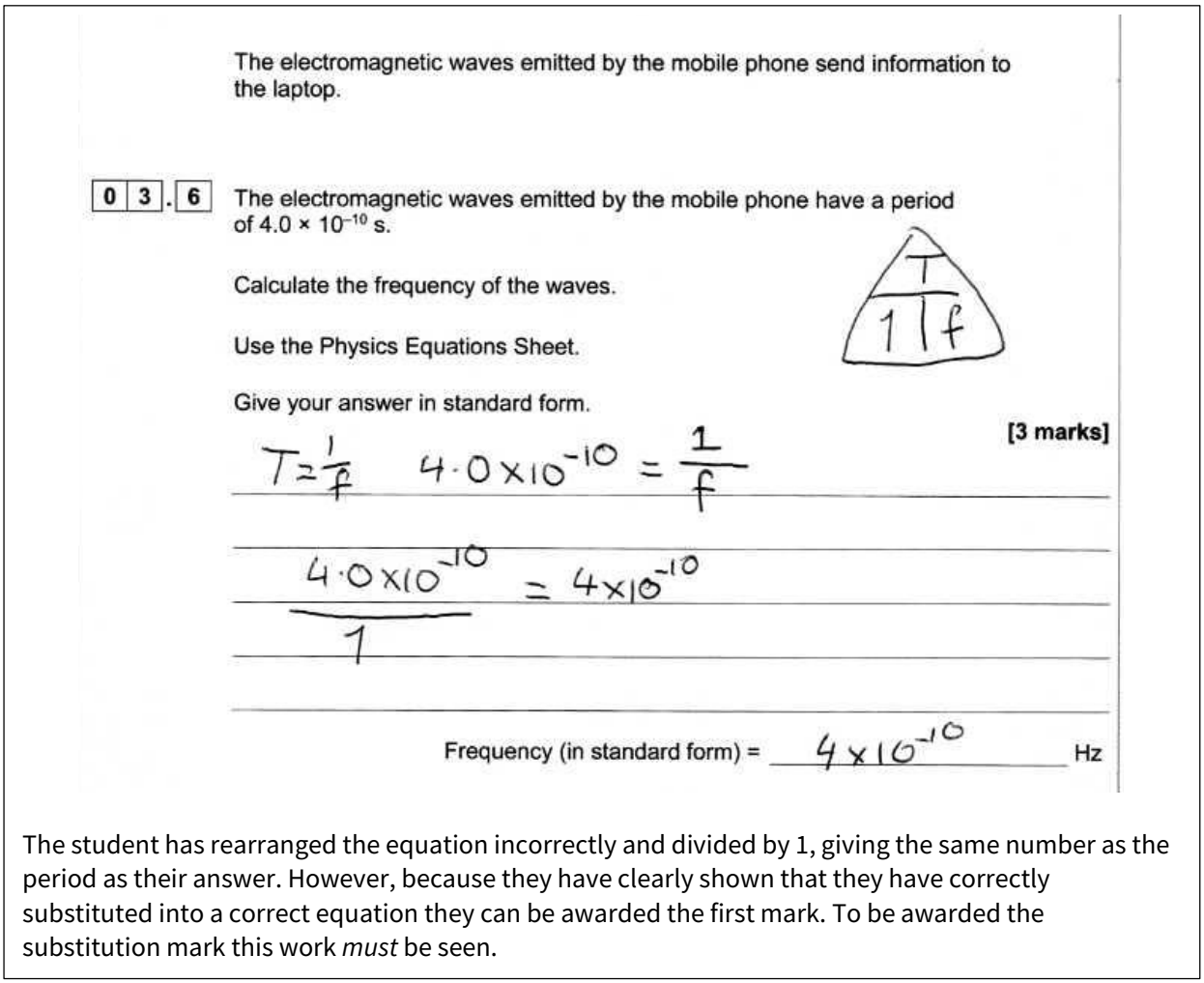
6.6.1.1 Transverse and longitudinal waves

Answer 05 · Examiner comments June 2024 | 8464/P/2H | Original Q3

03.4 Just over 25% of students gave the correct colour for the shortest wavelength of visible light. Most of those that gained the mark did write violet but some stated purple, which was allowed. The most common incorrect answer was red, but a wide range of colours was given, including black and white.

03.5 Nearly 75% of students gained at least 1 mark for giving a risk, although less than 20% of students listed the three groups and correctly linked each to a specific risk such as UV causes skin cancer. Most of the 1-mark answers gained the compensation mark for stating that high-frequency electromagnetic waves cause cancer.

03.6 This question required students to manipulate numbers in standard form and 60% of students gained all 3 marks. The equation is relatively simple as it contains only two variables. However, this seemed to throw some students, who substituted correctly but then rearranged incorrectly and multiplied the period by one, so gave their final answer as the same number as the period. Approximately 10% of students inputted the power of ten incorrectly into their calculators; these students were, however, still able to score 2 marks.



The electromagnetic waves emitted by the mobile phone send information to the laptop.

0 3 . 6 The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

[3 marks]

$T = \frac{1}{f}$ $4.0 \times 10^{-10} = \frac{1}{f}$

$\frac{4.0 \times 10^{-10}}{1} = 4 \times 10^{-10}$

Frequency (in standard form) = 4×10^{-10} Hz

The student has rearranged the equation incorrectly and divided by 1, giving the same number as the period as their answer. However, because they have clearly shown that they have correctly substituted into a correct equation they can be awarded the first mark. To be awarded the substitution mark this work *must* be seen.

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6.6.1.1 Transverse and longitudinal waves

Answer 05 · Examiner comments June 2024 | 8464/P/2H | Original Q3

The electromagnetic waves emitted by the mobile phone send information to the laptop.

0 3 . 6 The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

[3 marks]

Period = 1 / Frequency



Frequency (in standard form) = 4×10^{-10} Hz

This example demonstrates the importance of showing working. The student's answer (like that in the previous example) is the same as the period of the wave. However, this student is not awarded the first mark because the substitution is not seen and it is therefore not clear that they have actually done anything with the calculation.

03.7 The concepts being assessed in this high-demand question are very abstract and complex. Some students had obviously learnt this and wrote excellent explanations. 10% of students scored more than 1 mark.

6.6.1.1 Transverse and longitudinal waves

Answer 06 · Examiner comments June 2025 | 8464/P/2H | Original Q3

Question 3 (Standard, standard/high and high demand)

03.1 About a quarter of students were able to give a complete and correct definition of a transverse wave, with just under a fifth giving a definition that gained partial credit.

03.2 Nearly two thirds were able to give another risk caused by exposure to ultraviolet.

03.3 Just over 60% identified that ultraviolet has a shorter wavelength than visible light.

03.4 Giving an answer in nm proved to be very challenging, with just under 10% managing to work out the correct final answer.

A surprisingly large proportion of students struggled to calculate the correct power of ten to their answer, with working such as $\frac{3\times10^{8}\ \text{m/s}}{6.25\times10^{14}\ \text{Hz}} = 4.8\times10^{21}\ \text{m}$ being relatively common. Students who did this could then go on to convert their calculated value into nm and gain the final mark, but it was very common for students to multiply their answer by 10^{-9} instead of dividing by 10^{-9}, so the final mark was not often gained. Many students who attempted the conversion to nm thought that nano referred to 10^{-3} or 10^{-6}.

0 3 . 4 A wave of visible light has a frequency of 6.25×10^{14} Hz.

speed of light = 3.00×10^{8} m/s

Calculate the wavelength of this light.

Use the Physics Equations Sheet.

Give your answer in nanometres (nm).

[4 marks]

wave speed = frequency x wavelength.

wave speed / frequency = wavelength.

$3.00\times10^{8} / 6.25\times10^{14} = 4.8\times10^{21}$ m

$4.8\times10^{21} / 1000 = 4.8\times10^{18}$ nm

Wavelength = 4.8×10^{18} nm

This student correctly substituted into and rearranged the equation but made errors when calculating the wavelength in metres. This answer also illustrates the difficulties many students had in converting a value from metres to nanometres.

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6.6.1.1 Transverse and longitudinal waves

Answer 06 · Examiner comments

June 2025 | 8464/P/2H | Original Q3

03.5 Students struggled to explain why refraction occurs using the idea of wavefronts. It was very common for students to refer to the density of the glass, and sometimes to optical density. All of these references were ignored. Some students recalled that the wave speed changes but did not make it clear whether they thought the waves were increasing or decreasing in speed, so did not score any marks. Only about a fifth of students gained any credit in this question.

03.6 About four in ten students gained at least one mark, with approximately 20% giving a fully correct answer. The refracted rays drawn were in many different directions, but those who were able to draw the ray in the correct direction usually did so with accuracy and gained the second mark, and those that did not score the second mark tended to draw their refracted rays in completely the wrong direction. Some students gained the mark for drawing the refracted ray without having drawn a normal.

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