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INTERNATIONAL QUALIFICATIONS

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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

June 2025

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256XPH02/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from www.oxfordaqa.com

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Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no mark

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	The minimum frequency of electromagnetic radiation that results in electrons being emitted (from the metal surface) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	$E_{k(max)} = eV_{STOP}$ **OR** $E = hf$ used at any point ✓ Use of photoelectric effect equation to find ϕ ✓ 5.1×10^{14} (Hz) ✓	Combining eV and the photoelectric effect equation gets MP1	3	AO1

Total			**4**

Question	Answers	Additional comments/Guidelines	Mark	AO
02	Any **two** from: ✓✓ • Uses $d = \frac{10^{-3}}{280}$ or equivalent • Uses $d\sin\theta = n\lambda$ (with $\theta = 90$) **OR** $n\lambda = d$ to find n • Doubles their n and adds 1 11✓	expect 3.6×10^{-6}; condone POT error Rearrangement or correct substitution for MP2 n must be integer for final answer (full marks for correct final answer $= 11$ bright spots)	3	AO1

Total			3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Reference to wave equation **AND** frequency stays the same ✓	Accept proportionality statement for the wave equation Or reverse argument	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	*Due to an error in the question paper, this item has been discounted. All candidates have been awarded one mark.* $\left(\frac{\sin 53}{\sin 31} =\right) 1.6$ ✓	(1.55)	1	AO2

Total			**2**

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	2.5 (s) ✓ Idea that there are two maxima/minima (of energy/of height) in one period ✓	If no other mark awarded, condone, for 1 mark, 1.25s and idea of the time between adjacent peaks/troughs (of energy/height)	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Use of $T = 2\pi\sqrt{\frac{l}{g}}$ ✓ 1.6 (m) ✓	ecf from **04.1** for both marks	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Any **one** from: ✓ • the motion is damped/there is air resistance/friction • the motion is driven/the child kicks her legs/the child shifts her centre of mass (relative to the seat) • the angle of oscillation is not small • the child is not a point mass / mass of chain is significant • the chain does not stay taut	For BP2, accept 'the child shifts her weight'.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Sinusoidal shape ✓ Decreasing peaks ✓ Minima touching x-axis at 0, 1.25, 2.5; Maxima halfway between these points ✓	MP1 requires a flat gradient at peaks and troughs, and a constant period MP3: correct to quarter of a grid square by eye	3	AO2

Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Defines polarisation OR Describes longitudinal/transverse ✓ Both, with some link (may be implied) ✓	(Plane) polarisation is when the direction of oscillation is restricted to a certain plane (perpendicular to the direction of propagation of the wave) The idea that there are no oscillations perpendicular (to the direction of propagation) in longitudinal waves**/** only transverse waves have oscillations perpendicular (to the direction of propagation)	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Idea of aligning receiver/antenna with (polarised) signal (for signal transmission) ✓ Idea that mobile phones can be held in different orientations ✓	 Ignore idea that phone must receive signal from different directions	2	AO2

Total			**4**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Read-off = 1.6(0) (V) ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Deriving r algebraically **OR** relating r to V_{max}, I_{max} **OR** relating r to gradient ✓ Gradient/correct ratio determined using points far apart ✓ 0.19 (Ω) ✓	Expect to see eg $\frac{(-)1.6}{8.6}$ **ecf** on 6.1	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Lamp with **B** is brighter because: Any **two:** ✓✓ • less lost volts • higher terminal pd/higher pd across the lamp • less <u>total</u> resistance • greater current • valid application of a power equation		2	AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Sketch shows the light totally internally reflecting multiple times in the water jet ✓	Lines must be straight, judged by eye Reject if ray leaves water jet	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Line travels straight to water−air boundary, then refracts downwards at boundary then travels straight to screen ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	The angle of incidence of the light (decreases and) becomes less than the critical angle ✓ so the light refracts (out of the water) / no longer totally internally reflects ✓ Comparison of speeds of light or refractive indices AND comparison of angle of incidence and angle of refraction ✓	Accept eg 'light speeds up in air so it bends away from the normal'	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Any **one** from: ✓ • put a warning sign on the door • idea of not using lasers at eye level • do not point lasers at the audience • direct lasers at a screen • keep lasers stored safely (locked etc) • use lasers with an 'on' button that must be held down • use non-reflective screen.	Condone laser eye protection goggles Do not accept simply 'goggles' unless it is clear they are specifically for laser protection Condone stand behind the laser Ignore 'do not look at the laser (beam) directly'	1	AO4

Total			**6**

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Any **two** from: ✓✓ • energy is transferred along a progressive wave, but is stored/not transferred in a stationary wave • the phase of the oscillations varies continuously along a progressive wave, but is constant between two adjacent nodes/antinodes in a stationary wave • stationary waves have nodes/antinodes, while progressive waves do not **OR** the peaks and troughs (or compressions, rarefactions) move in a progressive wave but don't in a stationary wave • a progressive wave can have the same amplitude at all points whereas the amplitude varies along a stationary wave		2	AO1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>08.2</td>
<td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2-mark (L1),
3 or 4-mark (L2) and 5 or 6-mark (L3) answer.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered with at least two aspects covered in some detail.
Full marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A fair attempt to analyse all three areas, with two areas covered successfully and one partially.</td></tr>
<tr><td>4</td><td>Two areas fully covered, or one fully covered and two others covered partially.
Whilst there will be several gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area fully covered and one covered partially, or all three covered partially. There are likely to be several errors and omissions.</td></tr>
<tr><td>2</td><td>Only one area fully covered or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>One area partially covered</td></tr>
<tr><td>0</td><td>No relevant comments</td></tr>
</table>
</td>
<td>
• the measurements to be taken, including details of the measuring instruments used
• measure (hanging) mass with mass balance or weight with newtonmeter (condone use known masses)
• measure L with ruler or tape measure
• vary (hanging) mass or tension
• measure f for a harmonic using the signal generator

• techniques to reduce the uncertainty in the experiment, such as (two of the following):
• at least 6 values of (hanging) mass used
• repeat determination of f and average / remove anomalies
• idea of increasing frequency slowly past harmonic then back again
• method of reducing parallax error in determination of L
• idea of reducing friction in pulley

• how μ is determined using a graphical method
• calculate T using T=mg (unless newtonmeter used)
• valid combination of x and y variables for axes
• algebraic manipulation of $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ into the form $y = mx + c$ (may be implied)
• express μ in terms of the gradient

Accept answers in terms of any harmonic
</td>
<td>6</td>
<td>2 × AO1
4 × AO4</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Idea that the second harmonic has a node (in the centre) and it is easier to observe a node than an antinode ✓	Ignore 'more nodes'	1	AO4

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Max **two** of: ✓✓ • idea that atoms de-excite and emit photons OR atoms absorb photons and excite • Photon energy is equal to the energy of each transition • link between energy of photon and wavelength/frequency Idea that only specific wavelengths/frequencies are emitted/absorbed ✓	Condone electrons for atoms Explanation must be in terms of photons for MP1/2 May be in the form of an equation For MP3, we need the idea of what 'discrete' means, eg specific, certain, quantised	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Any **three** from: ✓✓✓ • use of $E = \frac{hc}{\lambda}$ • converts from eV to J correctly or vice versa at any time • determines $1.9\ \text{eV}$ using the wavelength • shows $-1.51 - -3.39\ \text{eV} = 1.9\ \text{eV}$ Concludes level 3 to level 2 ✓	Ignore signs in the subtraction Some valid working required for full marks	4	3 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	6		1	AO3

Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Micrometer (screw gauge) / digital (Vernier) calipers ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Fully close micrometer/calipers and then zero before taking readings **OR** Take reading of micrometer/calipers fully closed and subtract zero error from measurements ✓	condone: check for zero error and idea of removing it (numerically or practically) must have the idea of the two operations	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Idea of determining whether wire has circular cross-section/uniform thickness ✓	Accept: idea that the wire does not have circular cross-section/uniform thickness	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Any **two** from: ✓✓ • calculates mean d having removed anomaly (expect 0.17 mm) • uses $\frac{\frac{1}{2}\text{range}}{\text{their } \bar{d}}$ $(\times 100)$ to find % uncertainty in d • $2 \times$ their % uncertainty in d to find uncertainty in A 12% ✓	Only first bullet point and final answer require anomaly to be removed 1 or 2 sig fig only for final mark	3	1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.5	% uncertainty in length (= $1(.2)\%$) ✓ (adds the percentage uncertainties) = 13% ✓	Ecf on **10.4** No sig fig penalty here	2	AO3

Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Read-off from **Figure 15** for 37 °C (7.5 to 8.0 kΩ) ✓ Use of potential divider equation or other valid method to find R ✓ Answer that rounds to 2100−2200 Ω ✓	Allow POT error for MP1,2 If current is calculated, expect 2.9 to 3.1 x10^{-4} A	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	**R** has a larger share of the voltage (for any particular temperature) **OR** the current in the circuit decreases **OR** idea of maintaining voltage ratio ✓ Idea that the voltage of the thermistor is decreased (for the same resistance) **OR** the resistance of the thermistor needs to be higher (for the same pd)✓ Idea that the threshold voltage is reached/the indicator light turns on at a lower temperature ✓	For MP1, allow clear algebraic argument	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	Idea that a different threshold temperature/bathwater temperature can be chosen✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	Very high resistance **AND** idea that it does not affect the current/resistance of parallel section ✓	Accept so it does not affect V_{AB}	1	AO3
Total			**8**	

Question	Key	Answer	AO
12	D	$60\ \Omega$	AO3
13	D	1.3 W	AO1
14	A	$\frac{V}{R}$ | 0 | V	AO1
15	D	$6\ \Omega$	AO2
16	A	$0.87I$ $0.87P$	AO1
17	B	$1.2f$	AO1
18	D	24 cm	AO1
19	B	0.64 m	AO1
20	C	y	AO1
21	A	decreases increases	AO2
22	C	$\frac{L}{v}\left(\frac{1}{\cos\theta}-1\right)$	AO2
23	C	acrylic Teflon	AO1
24	B	ultraviolet photons visible photons	AO2
25	B	increases increases	AO2