OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
PHYSICS
PH05

Unit 5 Physics in practice

Mark scheme

January 2024

Version: 1.0 Final

2 4 1 X P H 0 5 / M S

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

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 marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	Idea that random errors are reduced by repeating and averaging ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	89.4 (cm) **cao** ✓	3 sf answer only	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Idea that the measurements are precise because they lie within a small range of values ✓	Accept idea that they are close to the mean value	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Calculates g as $9.28\ \mathrm{m\ s^{-2}}$ ✓ Measurements are not accurate because answer is far from the accepted value (of $9.81\ \mathrm{m\ s^{-2}}$) ✓	Accept 9.27 to 9.29 Accept: calculation of percentage difference in accepted and calculated value (expect to see ~ 5%) and a comment that this is large so the value is not accurate. OR calculation of absolute uncertainty (expect to see 0.2) in measured g and shows that the accepted value does not lie within the range.	2	AO2 AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Numerical comparison between values obtained using uncertainties in measured value and accepted value.	Expect to see $2.1\% < 5\ \%$ **OR** $9.81 > 9.28 + 0.2$ **OR** $9.81 - 0.2 > 9.28$ Accept reference to g for 9.81	1	AO4
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Idea that percentage error decreases as count increases OR percentage error $= \frac{100}{\sqrt{N}}$ ✓ Student **A**'s percentage timing error is greater than student **B**'s (due to having the same absolute error over a shorter period) ✓	Accept $\frac{1}{\sqrt{N}}$ or $\frac{\sqrt{N}}{N}$ If it is unclear, assume answer is referring to student **A**.	2	AO3 AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Calculates a percentage timing uncertainty **AND** a percentage count uncertainty ✓$_1$ Calculates both mean count rates ✓$_2$ Aggregates a percentage correctly for her or his timing and count uncertainty ✓$_3$ Finds at least one range correctly for their values **OR** the min value of A and max of B ✓$_4$ Deduces that they could be the same source as the ranges overlap **cao** ✓$_5$	Expect to see for ✓$_1$ 1.7% or 2% for **A** and/or 0.3% for **B** for timing **AND** 4.6% for **A** and/or 2.2% for **B** for count Expect to see $7.7\ \text{counts s}^{-1}$ for **A** or $7.2\ \text{counts s}^{-1}$ for **B** 6.3% for **A** or 2.5% for **B** seen gets ✓$_1$✓$_3$ Ranges of 7.2 (counts s^{-1}) to 8.2 (counts s^{-1}) for **A** and 7.0 (counts s^{-1}) to 7.4 (counts s^{-1}) for **B** gets ✓$_1$✓$_2$✓$_3$✓$_4$	5	4 × AO2 AO3
Total			**7**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>03</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. Guidance provided in section 3.10 of the ‘Mark Scheme instructions’ document should be used to assist marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas (as outlined alongside) covered fully.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>Two areas fully covered and one covered 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 gaps, there should only be only 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 in the discussion.</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 of the three areas partially covered.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table></td><td>For an area covered partially at least one bullet point should be seen. More than half of the bullet points should be seen for a fully covered area.
Measurements and safety
• measures distance between grating and screen (D) and distance between zero-order and named-order maximum (x) (using a metre ruler)
• do not look directly into laser beam OR use a matt screen.
Process of results
• uses $d\sin\theta = n\lambda$
• number of lines per mm is $\frac{1}{1000}\frac{1}{d}$ (with d in m or valid alternative if d is not in m)
• uses $\frac{x}{D} = tan\theta$
Ensuring accuracy
• measures the double angle either side of the zero-order maximum (to reduce uncertainty)
• chooses a higher-order maximum (to reduce uncertainty)
• uses distance between grating and screen of approximately 1 m
• repeat and average.</td><td>6</td><td>6 × AO4</td></tr>
</table>

Total			6

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Good choice of scales for I^{-1} axis ✓ Correct plotting of at least 3 points ✓ Correct plotting of all points ✓ Good best-fit line ✓	Expect to see y-axis increments of 0.20 or 0.25 Only award MP2 and MP3 for a readable scale	4	4 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Evidence of use of large triangle **AND** candidate's $\Delta(I^{-1}$ / $\mathrm{A}^{-1})$ divided by candidate's $\Delta(l)$ ✓ Answer that rounds to 2.3 to 2.4 $(\mathrm{A}^{-1}\ \mathrm{m}^{-1})$ ✓	Look for $\Delta(l)$ > 0.4	2	2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Uses $A = \pi \frac{d^2}{4}$ ✓ Uses $their\ gradient = \frac{\rho}{EA}$ ✓ Answer in the range 1.13×10^{-6} to 1.18×10^{-6} (Ω m) **ecf from 04.2** ✓	Candidates who use individual data from **Table 3** gain 1 mark only **cao** Allow ecf for using $A = \pi d^2$ answer in range 4.52×10^{-6} to 4.72×10^{-6} (Ω m)	3	AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Finds I^{-1} intercept in the range 0.20 to 0.35 $\mathrm{A^{-1}\ m^{-1}}$ ✓ Candidate multiplies his or her intercept by 3.0 ✓		2	AO2 AO3
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Takes logs of both sides correctly ✓ Convincing rearrangement including dealing with the $\frac{1}{2}$ and the separation of the terms ✓	Expect to see $2\ln(T) = \ln\left(\frac{4\pi^2}{GM}\right) + 3\ln(r)$	2	AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Explains that the gradient should be (determined and compared with the theoretical value of) 1.5 ✓	Mark available to the candidate who performs the determination and comparison	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Clear attempt to find the intercept by finding the equation of the line or by similar triangles ✓ Determines an intercept on the $\ln(T\,/\,\mathrm{s})$ axis in the range -21.25 to -20.85 ✓ Answer in the range 7.6×10^{29} to 4.6×10^{30} (kg) ✓	Accept of use of a point $(\ln(r), \ln(T))$ and 1.5 = $\frac{\ln(T) - intercept}{\ln(r)}$	3	2 × AO3 AO4
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	The system is heated (from the surroundings) **AND** work is done on it (by the paddle wheels) ✓ Internal energy of the system increases linked to $\Delta U = Q + W$ ✓ Temperature rise linked to increase in internal energy ✓		3	AO1 AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Uses $\Delta E_{\text{p}} = mg\Delta h$ using the correct mass ✓ Number that rounds to 8240 (J) ✓	Condone lack of factor of 2 and/or 20 for MP1 No sf penalty – expect to see 8242 J. Condone use of 9.8 for g to give 8233 (J) Accept 3 sf answer with correct data.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	3 significant figures since g is only given to 3 significant figures OR smallest number of significant figures of data used is 3 (and therefore the answer cannot be given to more) ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	MAX 2 ✓✓ Idea that the forces opposing the motion are negligible when the paddles are moving slowly (so the resultant forces on the masses is approximately their weight) Idea that the resistance/drag/viscous forces increase as the paddles move faster idea that the speed is constant when the resistive forces are equal and opposite to the weight/resultant force is zero		2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	0.050 (J) ✓	Calculator value is 0.0497668455 (J)	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.6	Idea that ΔE_p = work done on water + ΔE_k of masses ✓ Idea that the small magnitude of ΔE_k makes it insignificant (compared with the work done on the water) ✓	Condone missing factor of 20 in the ΔE_k calculation. Some comparison of numbers required for MP2	2	AO2 AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
06.7	Use of $Q = mc\Delta\theta$ ✓ Use of either 0.304 K or 7880 J ✓ 4150 (J kg^{-1} K^{-1}) ✓		3	2 × AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.8	Finds tension in string = 13.158×9.81 ✓ Uses $6{:}1$ gearing of the pulley OR equates the torques exerted by T_1 and T_P or T_2 and T_Q ✓ Uses torque = tension × radius to give $0.86(1)$ to at least 2 sf ✓	Expect to see a factor of $\frac{5}{30}$	3	AO1 AO2 AO3

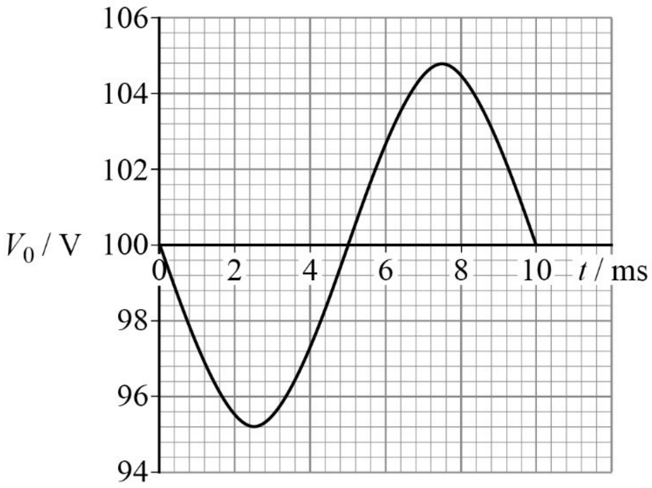
Question	Answers	Additional comments/Guidelines	Mark	AO
06.9	Uses power = torque × angular velocity ✓ 18 or 18.4 or 18.5 or 19 (rad s^{-1}) ✓	Expect to see $\frac{8240}{519} = 0.86\omega$ Use of 0.9 'show that' value for torque gives 17.6 (rad s^{-1}) Allow 1 max for including factor of 20 leading to 0.92 (rad s^{-1}) Accept alternative methods.	2	AO2 AO3
Total			**19**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Uses $C = \frac{A\varepsilon_0}{d}$ ✓ Correct calculation leading to 9.04×10^{-5} (m) ✓	Substitution or rearrangement	2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Uses $V = V_0\left(1 - e^{-\frac{t}{RC}}\right)$ ✓ 206 (s) ✓	Accept wrong powers of 10 for MP1	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Resistance of the resistor (in series with the capacitor) is very high ✓$_1$ Current will be low so rate of change of charge on capacitor will be small ✓$_2$ OR Time constant is very large compared with the periodic time of the oscillation ✓$_1$ Charge moved is (very) small in time of one oscillation ✓$_2$	Accept the idea that the time for an oscillation is so small that there isn't time for the charge to change for 1 mark if there is nothing else markworthy Allow idea that the voltage is constant and the change in capacitance is (very) small ✓$_1$ Therefore the charge moved is (very) small✓$_2$ Allow : calculation charge moved in one oscillation✓$_1$ comparison with charge on capacitor and statement charge moved is small. ✓$_2$	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Capacitance increases (since d decreases) ✓ pd decreases with reference to $Q = CV$ ✓ pd drops to $0.95\ V$ (since increase in capacitance is 5%) ✓	Accept $95\ \mathrm{V}$	3	AO1 AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Sinusoidal variation about $V = 100\ \mathrm{V}$ with scales and axes correct ✓ Any 2 from: Amplitude consistent with candidate's **07.4** Period of sinusoidal oscillation $10\ \mathrm{ms}$ negative sine form ✓✓		3	3 × AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Extracts data correctly as 4.4×10^{14} **AND** uses $c = f\lambda$ ✓ Uses $\lambda_{\text{peak}} = \dfrac{2.90\times10^{-3}}{T}$ 4300 (K) ✓	Accept 4.35 to 4.45 Accept answers that round to 4200 or 4300	2	2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Dips in intensity indicate that there are changes of energy levels (in the atom) ✓ photon energies/ energy levels are characteristic of an atom (of a particular element)✓	Do not accept answers restricted to excitation from ground state for MP2.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	$3 \times 10^8 \times 365 \times 24 \times 3600$ seen to give 9.46×10^{15} to at least 3 sf ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Uses $I = \frac{P}{4\pi r^2}$ ✓ $\frac{I_A}{I_S} = \frac{P_A}{P_S} \bullet \left(\frac{r_S}{r_A}\right)^2$ ✓ 6.3×10^{-11} ✓	Evidence of MP1 can be seen in MP2	3	2 × AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Uses $F = \frac{GMm}{R^2}$ OR $F = mr\omega^2$ ✓ Uses $R = 8 \times 10^{13}$ AND $r = 2.35 \times 10^{13}$ ✓ Uses $T = \frac{2\pi}{\omega}$ ✓ Use of M consistent with their r to give 9.5×10^{10} (s) ✓	If $r = r_A$ then $M = M_B$ If $r = r_B$ then $M = M_A$	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.6	Idea that, if they had different periods, the centre of gravity would no longer be in the line between them ✓		1	AO2
Total			**13**	