AQA

A-LEVEL
Physics

Investigative and Practical Skills in A2 Physics – PHY6T/Q15
Final Marking Guidelines

Specification 2450/2455
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Version/Stage: Final Marking Guidelines

Guidance for teachers marking Physics ISAs

The marking guidelines have been devised by a team of experienced examiners. They have tried to anticipate all possible responses worthy of credit. In order to establish consistency it is essential that all centres mark exactly to this scheme.

For ease of use the mark scheme has been presented in tabular form. Concise answers are given in the left-hand column. More detailed explanatory notes for some questions are included in the right-hand column.

Marking of Stage 1 of the ISA – student data and graph – should ideally be completed before the ISA written test to ensure that candidates do not change any data. (Alternatively, centres should take other steps to ensure that candidates do not change any information on their data script/graph). The marking of this section should be annotated with a red tick at the point where the mark has been awarded together with the letter referring to this mark scheme, eg '✓b'. **No other comments or feedback should be written on the candidates' scripts**. The total mark for this section should be written at the top of the paper. This will be transferred to the grid on the front page of the ISA test booklet.

Marking of the ISA test should be done using a red tick to represent each mark awarded. Further annotated comments **can** be added where necessary as an explanation as to why a particular point has been awarded which will greatly aid the moderation process. The total mark for each question should be entered on the grid on the front cover of the ISA booklet and the total mark calculated. Assessment Advisers are allocated to each centre and they can advise on the marking process. You should receive the contact details for the Assessment Advisor through the post. If you have not received them, please contact the AQA subject team.

Stage 1		Mark	Additional guidance notes
(a)	Table with column headings showing all recorded values for *m* and at least 10*T*. Units correct in column headings for the measured data and mean values✓	1	Column headings can be either in words or appropriate symbols. Units can be in words or the correct abbreviation. Do not allow secs for seconds. There must be a suitable separator between the quantity and its unit. e.g. *m*/kg or *m*(kg) or *m* in kg *This mark cannot be awarded to candidates who include units in the body of the table.*
(b)	All raw data recorded to the precision of the instruments provided and mean values for *T calculated from at least two timings for all six values of m.*✓	1	i.e. mass quoted to nearest gramme and times quoted to precision of stopwatch (ie 0.01s) No sf or dp penalty here on mean value calculations *Only award this mark if the candidate has clearly timed* ***full oscillations and not half oscillations****.*
(c)	A **mean value for *T*** correctly calculated in the **first and third** row of the table. ✓	1	Both answers quoted to 2 or 3 sf and consistent with all other values of *T* in the table.
(d)	Tabulated values of T^2, including unit, s^2, given for all six rows in the table. Check for correct calculation from the tabulated value for *T* in the **first and third** row of the table. ✓	1	No sf penalty for T^2
(e)	A graph of T^2 against *m* with T^2 on the vertical axis. Suitably large graph scale (do not award if scale on either axis could have been doubled). Scale must have 'sensible' divisions which can be easily read, e.g. scales in multiples of 3,6,7,9 etc are not acceptable. Both axes must be labelled with quantity and unit. ✓	1	For axes labels, the same convention as for table headings is required. Allow ecf from (b) for an incorrect unit or no unit. If the axis label and the corresponding table heading have different unit errors then penalise both A scale division in 4's might sometimes be acceptable.
(f)	Points accurately plotted to within 1 mm ✓ *Markers should check the first and third plotted points on the graph*	1	This mark is independent of mark (e). ie if a candidate has used an unsuitable scale he/she can still achieve the mark for accurately plotting the points.
(g)	Accurate straight line of best fit well drawn ✓	1	The line should have an approximately equal number of points on either side. Points which are obviously anomalous should not unduly influence the line.
	Total	**7**	

Section A		Mark	Additional guidance notes
1(a)	Mass or *m* ✓	1	
1(b)	Measure from the bench to the ruler at both ends✓ Use set-square to adjust springs so as to be perpendicular to rule.✓ **Or** Use the plumb line to ensure that the springs are vertical✓ Use the set square to check that the ruler is perpendicular to the springs ✓	2	.
1(c)(i)	The fast oscillations/small periods are difficult to measure/count accurately **Or** Other modes of oscillation occur more easily✓	1	
1 (c)(ii)	a) Timing multiple oscillations to reduce percentage uncertainty in timing b) Use fiducial marker at centre of the oscillations as this precisely identifies the beginning and end of oscillation/ruler travels fastest at centre making it easier to identify exact time at which it passes the marker c) Use oscillations with small amplitude to ensure SHM d) Allow transient oscillations to die down before starting to time the motion since transient oscillations may have a varying *T* e) Use 'count down' technique for starting timing since it is difficult to start the stopclock and release metre ruler at same time f) Use 'count down' technique for starting timing so that oscillations can be timed using the fiducial marker at the centre of the motion g) Take repeat readings to reduce the uncertainty in the timings/check reliability **✓✓✓3 marks max**	3	**Each mark requires a statement <u>and</u> an explanation.** ***Award up to three marks from the seven marks available*** *Place a tick clearly near the appropriate point in the text for each mark awarded, and annotate the tick with the corresponding letter (eg. ✓a)*

Question		Mark	Additional guidance notes
1 (d)	The relationship is linear (but not directly proportional) ✓ (Because) the straight line graph does not pass through origin ✓	2	Alternatives for first mark: *Increase* in *m* / the graph shows a relationship of the form $T^2 = km + c$ Allow both marks for a candidate whose line goes through the origin for a statement saying that the quantities are (directly) proportional ✓ because it is a straight line through the origin. ✓
1 (e)(i)	The *weight* of the ruler keeps the springs in tension/ extends the springs✓	1	Do not allow mass instead of weight. Do not allow "spring has passed its elastic limit".
1(e)(ii)	The graph does not pass through the origin✓	1	
1(f)	The gradient of the graph = $4\pi^2/k_S$ where k_S is the stiffness of the system✓ $k = k_S/2$ ✓	2	
	Total	**13**	

<table>
<tr><th>Section B</th><th></th><th>Mark</th><th>Additional guidance notes</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>t_{mean}/s</th><th>T/s</th><th>log(k/Nm^{-1})</th><th>log(T/s)</th></tr>
<tr><td>4.91</td><td>0.491</td><td>2.167</td><td>-0.3089</td></tr>
<tr><td>4.51</td><td>0.451</td><td>2.236</td><td>-0.3458 ✓</td></tr>
</table>
</td><td>1</td><td>Exact answers only
Note: 4 sf is appropriate for the logs as one figure represents the characteristic (place value).</td></tr>
<tr><td>2(b)</td><td>Both points plotted to nearest mm. ✓
Straight line of best fit drawn through points. ✓</td><td>2</td><td>The line should reflect the trend of the plotted points and have an approximately equal number of points on either side.</td></tr>
<tr><td>2(c)</td><td>Triangle drawn with smallest side ≥ 8 cm and correct values read from the line of best fit✓

Gradient in the range -1.85 to -2.14 ✓✓
(-2 gets one mark only for the minus sign)</td><td>3</td><td>Two marks for the final answer: one mark for the minus sign and one mark for the magnitude (2 or 3 sf only).</td></tr>
<tr><td>2(d)</td><td>The equation suggests that $k \propto T^{-2}$ ✓

Hence log k = -2log$T$ + constant ✓

This gives a straight line graph with gradient -2 exactly✓

My gradient agrees/disagrees with this within experimental error✓</td><td>4</td><td>A correct stated log equation implies the first mark.

For the fourth mark the candidate must make a valid judgement and mention experimental error/uncertainty if applicable</td></tr>
<tr><td>2(e)</td><td>½ x range = (8.60 – 8.43)/2 = 0.085 (s)
% uncertainty = (0.085/8.51) x 100 = 1.0 ✓</td><td>1</td><td>Accept 1 or 2 sf only</td></tr>
<tr><td>2(f)</td><td>Random error
Arising from variation in reaction time ✓</td><td>1</td><td>Do not accept “human error”</td></tr>
<tr><td>2(g)(i)</td><td>% uncertainty in T^2 = 2 x 1.0✓
% uncertainty in m = (2 x 1.0) + 0.5 = 2.5✓</td><td>2</td><td>Allow ecf from 2(e). Accept 1 or 2 sf only in final answer
Both marks for the correct calculated answer of 2.5 or 3.</td></tr>
<tr><td>2(g)(ii)</td><td>Uncertainty = ± (900 x 0.025) = (±) 22.5 g</td><td>1</td><td>No sf penalty, but must have unit. Allow ecf from 2(g).
No penalty if ± sign is missing</td></tr>
<tr><td></td><td>Total</td><td>15</td><td></td></tr>
</table>

Question		Mark	Additional guidance notes
3(a)	Reference to both $f = 1/T$ and $T = 2\pi\sqrt{(m/k)}$ ✓ The natural frequency of the bridge will be affected by the mass of the bridge and the stiffness/spring constant/Young modulus of its supports✓	2	
3(b)	(a) Well-drawn diagram showing several springs in parallel arranged symmetrically along length of rule with a mass hung from centre. (b) The springs should be identical and the mass kept constant and at least 10 oscillations should be timed (c) Take repeat readings and find a mean value for T (d) Repeat with different numbers of springs to obtain at least 6 sets of values. (e) Plot a graph of $1/T$ against the number of springs. ✓✓✓✓ **4 marks max**	4	***Award up to four from the five marks available*** *Place a tick clearly near the appropriate point in the text for each mark awarded, and annotate the tick with the corresponding letter (eg. ✓a)*
	Total	**6**	