



**General Certificate of Education (A-level)
June 2013**

Physics

PHA/B3T

(Specification 2450/2455)

**Unit 3: Investigative and practical skills in AS
Physics**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners 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 examiner understands and applies it in the same correct way. As preparation for standardisation each examiner 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, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal 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.

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Marking Guidelines Explanatory Notes

The marking guidelines should be considered a working document. A version of the marking guidelines will be placed on the Secure Key Materials Website in September. This is to allow centre's to undertake ISA practicals as soon as they wish. Centres can use this version of the marking guidelines to mark candidates work. However this version of the marking guidelines may be subject to amendments. An updated version of the marking guidelines to be used during the present academic year will be placed on the Secure Key Materials Website by **31st October**. Examinations Officers must ensure that Teachers receive the final version of the marking guidelines. **Centres should ensure that their marking is in line with the updated version of the marking guidelines.**

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.

ISA (P) Forces in Equilibrium

Stage 1		Mark	Additional guidance notes
(a)	Single clear table with columns correctly headed with both quantity and unit ✓	1	Headings can be in words or symbols. Units can be in words or the correct abbreviation. Standard notation for quantity and unit is expected e.g. $\frac{M}{\cos\left(\frac{\theta_m}{2}\right)}/\text{kg}$ but accept units given inside brackets e.g. $\frac{M}{\cos\left(\frac{\theta_m}{2}\right)}(\text{g})$ Do not award this mark if any units are written in the body of the table
(b)	Six completed rows of data for $M = 100, 200, 300, 400, 500$ and 600 g. Each row must have four recorded values for length and two for angle θ . ✓	1	All values M should be given to the nearest gram. However allow 0.10 kg, etc but do not allow 0.1 kg, etc. All values of length must be given to the nearest mm and all values of θ to the nearest degree only.
(c)	Values of L and θ_m correctly calculated for $M = 200$ g and $M = 400$ g (i.e. 2 nd and 4 th readings). ✓	1	No sf penalty
(d)	$\frac{M}{\cos\left(\frac{\theta_m}{2}\right)}$ correctly calculated for $M = 200$ g and $M = 400$ g. ✓	1	No sf penalty but allow ecf from (c)
(e)	Suitably large graph scale (do not award if scale on either axis could have been doubled). Scale must have <u>sensible</u> divisions which can be easily read (e.g. not in multiples of 3, 6, 7, 9 etc.) and both scales must start at zero ✓	1	The plotted points <u>plus the origin</u> should occupy at least half of each axis.

ISA (P) Forces in Equilibrium

(f)	L plotted on the <i>y</i> -axis and $\frac{M}{\cos\left(\frac{\theta_m}{2}\right)}$ on the <i>x</i> -axis with both axes correctly labelled with quantity and unit✓	1	Allow error carried forward for incorrect unit(s) from the table, but otherwise no unit: no mark. <i>However, do not penalise here if the unit is missing both on the graph and in the table.</i>
(g)	First and fifth points from the <i>y</i> -axis accurately plotted to within 1 mm✓	1	This mark is independent of mark (e), i.e. candidates who have used an unsuitable scale can still achieve the mark for accurate plotting.
(h)	Suitable straight line of best fit drawn✓	1	A straight line with a positive gradient and a positive intercept on the <i>L</i> axis is expected, but credit any well drawn straight line that fits the trend and cuts the <i>L</i> axis if there is an even scatter of points about the line Points which are obviously anomalous should not unduly influence the line drawn.
Total		8	

ISA (P) Forces in Equilibrium

Stage 2 Section A		Mark	Additional guidance notes
1(a)(i)	Graph supports prediction because: Graph has a <u>positive</u> gradient ✓ Graph has a <u>positive</u> intercept on the L-axis (or y-axis) ✓ OR Graph does not support prediction because: Graph is not a straight line or graph does not have a positive gradient or graph does not have a positive intercept on the L-axis	2	One mark only can be awarded for the explanation if the graph does not support the theory.
1(a)(ii)	Answer is reliable because the points are close to the line of best fit ✓ OR Answer is not reliable because (some of) the points are not very close to the line of best fit	1	
1(a)(iii)	Value of B correctly found from intercept on the L-axis: value (probably between 4 and 6 cm) ✓ 2 or 3 sf with unit ✓	2	
1(a)(iv)	Length of spring when $M = 0$ ✓	1	Accept: the unstretched/original/natural length of the spring
1(b)(i)	Half the range or ± 1 mm if all values the same ✓	1	Allow missing \pm but a <u>correct unit</u> is required No sf penalty
1(b)(ii)	Half the range or ± 1 degree if all values the same ✓	1	Allow missing \pm No sf or unit penalty
1(b)(iii)	Both percentage uncertainties shown correctly calculated, together with a correct statement as to which is the larger (or if they are the same, a statement to that effect) ✓	1	Allow ecf from (b)(i) and/or (b)(ii)

1(b)(iv)	Statements to the effect that: % uncertainty in L is smaller with the larger mass ✓ % uncertainty in θ_m is greater with the larger mass ✓ Consistent conclusion ✓	3	Consistent conclusion: if in part (b)(iii) $\delta L\% < \text{or} = \delta\theta_m\%$ then the difference would increase and $\delta\theta_m\%$ would (still) be the larger if in part (b)(iii) $\delta L\% > \delta\theta_m\%$ then it is likely that $\delta\theta_m\%$ would now be larger than $\delta L\%$
	Total	12	

ISA (P) Forces in Equilibrium

Stage 2 Section B		Mark	Additional guidance notes						
2(a)(i)	$W = 2mg \cos \phi \quad \therefore m = W/(2g \cos \phi) \checkmark$	1	The question says <i>show that</i> , so the candidates must write down both steps.						
2(a)(ii)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">2.411</td> <td style="text-align: center;">0.793</td> </tr> <tr> <td style="text-align: center;">2.635</td> <td style="text-align: center;">0.856</td> </tr> <tr> <td style="text-align: center;">\checkmark</td> <td style="text-align: center;">\checkmark</td> </tr> </table>	2.411	0.793	2.635	0.856	\checkmark	\checkmark	2	One mark for each column: exact answers only.
2.411	0.793								
2.635	0.856								
\checkmark	\checkmark								
2(a)(iii)	Both points correctly plotted to the nearest mm \checkmark Well drawn straight line of best fit. \checkmark	2	The line should follow the trend of the points with an even scatter of points on either side of the line.						
2(b)(i)	Triangle drawn with smallest side at least 8 cm in length. \checkmark Correct readings taken from the line for the triangle \checkmark Gradient in the range 0.45 to 0.49 (0.445 to 0.494) quoted to 2 or 3 significant figures \checkmark	3	The size of the triangle can be identified from readings taken from the line. The third mark is independent of the other two: error carried forward for incorrect readings (or for a poor line of best fit) which give a gradient out of range is not allowed.						
2(b)(ii)	Candidate's answer for gradient in 2(b)(i) correctly multiplied by g (expected answer 4.6) \checkmark N \checkmark	2	No s.f. penalty. The second mark is for the unit and can be awarded if the numerical answer is incorrect.						
2(c)	$\delta x\% = 0.2$ and $\delta y\% = 0.5 \checkmark$ $\delta(x/y)\% = \delta x\% + \delta y\% = 0.2 + 0.5 = 0.7 \checkmark$ Use of $\delta(x/y)^2\% = 2 \times \delta(x/y)\%$ \checkmark	3	Final answer is (\pm) 1.4 (%) which automatically gains all three marks Otherwise Accept only 1 s.f. for 1 st and/or 2 nd marks. The third mark is for the method, not the final answer						

<p>2(d)(i)</p>	<p>Systematic errors in measurements are errors which show a pattern or a bias or a trend ✓</p>	<p>1</p>	<p>Some acceptable alternatives</p> <ul style="list-style-type: none"> • A systematic error is one which deviates by a fixed amount from the true value of a measurement • An error which has the same value in all readings • A difference between the true value of a quantity and the indicated value caused by a fault in the measuring device • Accept a good example of systematic error.
<p>2(d)(ii)</p>	<p>y would be larger ✓ because angle θ would be smaller or because friction would be opposing the increasing weight of m ✓</p>	<p>2</p>	
	<p style="text-align: right;">Total</p>	<p>16</p>	

ISA (P) Forces in Equilibrium

Stage 2 Section B		Mark	Additional guidance notes
3	(a) Weigh the box and its contents <u>each time</u> (b) (With $\theta = 0$) place the box on the slope and lift the end slowly until the box is just about to slide down the slope and measure angle θ . (c) Measure angle θ <u>with a protractor</u> . or Determine angle θ using <u>trigonometry</u> . (d) take <u>at least three</u> readings for θ for each value of W and <u>then average them</u> . (e) Repeat step (b) <u>at least four</u> more times with a larger weight inside the box each time. (f) Plot a graph of θ (or $\tan\theta$) against W . (h) Award this mark for good practical technique <p style="text-align: right;">✓✓✓✓✓ 5 marks max</p>	5	<p><i>Please note, next to your tick, put the letter corresponding to the marking point being awarded (e.g. ✓a).</i></p> <p><i>Some acceptable answers for mark (h)</i></p> <ul style="list-style-type: none"> • With the box in the same position as before, repeat step (b) • Distribute the extra weight evenly inside the box • Raise the ramp with a lab-jack for stability/to measure θ accurately • Clamp slope when θ found before measuring it
	Total	5	

ISA (Q) LED Characteristics

Stage 1		Mark	Additional guidance notes
(a)	Correct circuit set up. No mark if help was given setting up the circuit ✓	1	Allow LED connected the wrong way round initially
(b)	Table with all columns correctly headed quantity/unit showing all recorded results for both forward and reverse directions. ✓	1	Headings can be in words or symbols. Units can be in words or the correct abbreviation. Standard notation for quantity and unit is expected (e.g. //A) but accept units given inside brackets or other notation if the meaning is clear. <i>Do not award this mark if any units are written in the body of the table</i> Do not penalise readings recorded out of sequence.
(c)	Minimum of 7 different non-zero readings of current in the forward direction together with at least 2 readings in the reverse direction. ✓	1	
(d)	<u>All</u> data recorded to the precision of the meters used. ✓	1	This mark is only awarded if the candidate has correctly recorded the precision of both instruments.
(e)	Suitably large graph scale (do not award if scale on y-axis could have been doubled). Scale must have <u>sensible</u> divisions which can be easily read (e.g. not in multiples of 3, 6, 7, 9 etc.). pd scale starts at one volt: current scale starts at zero. ✓	1	Allow scale on x-axis, even if the scale could be doubled, since the scale must start at one volt.
(f)	Axes must be labelled with quantity and unit. ✓	1	Alternative methods of labelling axes as in (b) above for table headings. Do not penalise for unit if <u>same</u> error has already been penalised in (b).
(g)	First and fifth points from the <i>y-axis</i> accurately plotted to within 1 mm. ✓	1	This mark is independent of mark (e), i.e. candidates who have used an unsuitable scale can still achieve the mark for accurate plotting.

(h)	Correct line of best fit drawn. ✓	1	A single smooth and continuous curve is expected with a reasonably even scatter of points about the line. If the steep part of the graph is straight, this part of the line could be drawn with a ruler
	Total	8	

ISA (Q) LED Characteristics

Stage 2 Section A		Mark	Additional guidance notes
1(a)	To prevent overheating of the LED/ to limit current through the LED ✓	1	Do not accept “dangerous” comments
1(b)(i)	V/I used with correct values from the graph ✓ Giving correct final answer <u>with unit</u> ✓	2	No sf penalty but look out for mA current not converted into amperes
1 (b)(ii)	Both $\delta I\%$ and $\delta V\%$ calculated correctly ✓ $\delta I\% + \delta V\%$ calculated correctly ✓	2	The values quoted or implied for precision in Stage 1 must be used (\pm precision) Final answer: <u>1 or 2 sf only</u> since it is an <i>estimate</i>
1(c)	The resistance is high at low pd ✓ When the pd is over 1.5 V (typically) the resistance decreases (rapidly) ✓	2	The candidate must <u>quote their voltage</u> for the second mark
1 (d)(i)	Best fit straight line well-drawn for the linear part of the graph. ✓	1	Allow any straight line that passes through the last two plotted points
1(d)(ii)	Correctly extrapolated straight line for intercept <u>and</u> intercept on pd axis read off correctly <u>with unit</u> ✓	1	
1 (e)	Resistance is <u>very</u> large/infinite ✓	1	
	Total	10	

ISA (Q) LED Characteristics

Stage 2 Section B		Mark	Additional guidance notes
2(a)	5.31, 6.38 ✓	1	Exact answers only
2(b)	Both points correctly plotted to the nearest mm ✓ Well drawn straight line of best fit. ✓	2	The orange LED point (4.80, 1.54) is anomalous. The line should follow the trend of the points (ignoring the anomalous point) with an even scatter of points on either side of the line.
2(c)(i)	Triangle drawn with smallest side at least 8 cm in length. ✓ Correct readings taken from the line for the triangle. ✓ Gradient in range 0.44 to 0.46 (0.435 to 0.464) $\times 10^{-14}$ quoted to 2 or 3 significant figures ✓	3	The size of the triangle can be implied by readings taken from the line. The third mark is independent of the other two: error carried forward for incorrect readings (or for a poor line of best fit) which give a gradient out of range is not allowed. Unit not required for the mark.
2(c)(ii)	Possible marking points: The anomalous point makes the value less reliable. ✓ (However) the (other) points are close to the line of best fit. Suggesting that the value is reliable. ✓	2	If the candidate has not ignored the anomalous point when drawing the line of best fit accept: <i>The points are not close to the line of best fit so the value is not reliable</i> ✓ for one mark only
2(d)(i)	Recognition that the gradient = h/e ✓ $h = 0.45 \times 10^{-14} \times 1.60 \times 10^{-19}$ ✓ $= (6.95 \text{ to } 7.44) \times 10^{-34} \text{ Js}$ ✓	3	Allow ecf from 2(c)(i) for <u>second mark</u> (including wrong exponent) Final answer must be in range, have correct exponent, <u>correct unit</u> and be quoted to 2 or 3 sf
2(d)(ii)	$((7.2 \times 10^{-34} - 6.63 \times 10^{-34}) / 6.63 \times 10^{-34}) \times 100\%$ calculated correctly ✓	1	Allow ecf from 2(d)(i): <i>expected answer 8.6%</i> Allow $\frac{(7.2 \times 10^{-34} - 6.63 \times 10^{-34}) \times 100\%}{6.63 \times 10^{-34}}$ giving 7.9% No sf penalty
2(d)(iii)	$\pm 1.1\%$ or $\pm 1\%$ ✓	1	\pm is required here as it is explicit in the question

2(d)(iv)	%uncertainty in $f = 8.6 - 1.1 = 7.5\%$ ✓ $\therefore \delta f = \pm 0.075 \times 3.19 \times 10^{14}$ ✓ $= \pm 2.39 \times 10^{13} \text{ Hz}$ ✓	3	Allow ecf from 2(d)(ii) Final answer: 2 or 3 sf with unit but \pm symbol not required
2(d)(v)	Possible marking points: <ul style="list-style-type: none"> • Inaccurate extrapolation to find V_{\min} in first graph • Poor line of best fit in second graph • Contact resistance in voltmeter connections • Systematic error/zero error on voltmeter ✓✓ 2 marks max	2	
	Total	18	

ISA (Q) LED Characteristics

Stage 2 Section B		Mark	Additional guidance notes
3	<p>(a) Set up a circuit with an LED, an ammeter in series with the LED and a variable power supply.</p> <p>(b) Adjust the supply to give a suitable current.</p> <p>(c) Place the sensor at fixed distance from the LED throughout the experiment</p> <p>(d) Record the reading of the sensor, repeating the measurement several times, and then calculate the mean sensor reading</p> <p>(e) Repeat with each LED in turn using the same current each time</p> <p>(f) Compare the sensor readings for each LED: to see if they agree (within the uncertainties)</p> <p>(g) Sensible reference to the need to account for ambient lighting conditions</p> <p style="text-align: right;">✓✓✓✓✓ 5 marks max</p>	5	<p><i>Please note, next to your tick, the letter corresponding to the marking point being awarded (e.g. ✓a).</i></p> <p>Accept a good correct circuit diagram for mark (a)</p> <p>All three points required for mark (d)</p> <p>e.g. (mark (g)) “carry out the experiment in a darkened room”</p>
	Total	5	