



**General Certificate of Education (A-level)
June 2011**

Physics

PHA3/B3/X

**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 candidates' 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 candidates' 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.

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GCE Physics, PHA3/B3/X, Investigative and Practical Skills in AS Physics

Section A, Part 1

Question 1				
a	i	method	d from repeat readings, (all) to 0.01 mm ✓	1
a	ii	accuracy	SWG number = 22 ✓	1
b	i/ii	accuracy	V_1 and V_2 sensible, both to 0.01 or both to 0.001 V, V_1 in range $4V_2$ to $6V_2$ ✓	1
b	iii	accuracy	2 raw readings recorded to the nearest mm; x from the difference in raw readings in range 300 mm to 380 mm ✓	1
c	i	method	percentage uncertainty in $V_1 = \frac{0.01}{V_1} \times 100$ (eg where V_1 in V) expect at least 2 sf answer ✓ (allow ecf from bii)	1
c	ii	method	percentage uncertainty in $V_2 = \frac{0.01}{V_2} \times 100$ (eg where V_2 in V) expect at least 2 sf answer ✓ (allow ecf from bii) if both ci & cii results are given to 1 sf then only deduct one mark	1
d		method	percentage uncertainty in $R = (\text{sum of percentage uncertainties in } V_1 \text{ and } V_2) + 5\%$; max 4 sf result ✓ (allow ecf from c)	1
e		method	evaluates resistance per metre of wire using $\frac{R_{PQ}}{x}$ (expect evidence of calculation) ✓	1
		deduction	type of wire = constantan ; result for $\frac{R_{PQ}}{x}$ must be in range 1.14 to 1.49 (Ωm^{-1}) and SWG must = 22 ✓ (no ecf for wrong SWG and/or wrong resistance per metre)	1
			Total	9

Question 2			
a	observations	<p>θ_0 recorded with a unit; 6 sets of θ recorded in column 2 of Table 3, consistently to the nearest $^\circ$ (tolerate nearest 2° or nearest 5°), sensible values of θ, all greater than θ_0 and in ascending order ✓</p> <p>6 sets of $(\theta - \theta_0)$, correctly calculated (check at least one) ✓</p>	2
b	scale	<p>vertical scale to cover at least half the grid vertically; use of false origin should be marked properly ✓</p> <p>(allow reversed potentiometer and do not penalise here for false data)</p>	1
	points	6 plotted correctly to nearest mm (allow reversed potentiometer but give no credit for false or incorrectly calculated data; check at least two including any anomalous points; withhold mark for any thick or missing point(s)) ✓	1
	line/quality	<p>from a smooth curve of positive continuously decreasing gradient from $R = 1\text{ k}\Omega$ to $R = 39\text{ k}\Omega$ (tolerate 1 straight line section between adjacent points; maximum acceptable deviation is 2 mm, adjust criterion if poorly-scaled; allow smooth curve of negative continuously decreasing gradient for reversed potentiometer but give no credit for false data or thick/hairy line); no point to be further than 2 mm from best-fit line ✓</p>	1
c	method and accuracy	<p>θ_U recorded to the nearest $^\circ$ (do not penalise missing unit if already penalised for θ_0); evidence shown (eg on the graph) that position of $\theta_U - \theta_0$, correct to the nearest mm, has been used to determine R_U ✓</p> <p>value of R_U with appropriate unit, read off correct to the nearest mm, result in the range 8.1 kΩ to 10.1 kΩ (tolerate 9 kΩ, reject 10 kΩ) ✓</p>	2
Total			7

Section A, Part 2

Question 1			
a	accuracy	<p>negative V_{20} and positive V_{260}, with unit, values sensible (do not penalise for reversed polarity if consistent with (b))</p> <p>$\frac{V_{260}}{V_{20}}$, negative, 3 sf or 4 sf and same sf as for V_{20} and V_{260},</p> <p>no unit, result in range $-1.45(0)$ to $-1.38(0)$ ✓</p>	1
b	tabulation	<p>x /mm V /V ✓✓</p> <p>deduct ½ for each missing or wrongly-connected label</p> <p>deduct ½ for each missing separator, rounding down</p> <p>penalise if x/mm is not in the left-hand column of the table</p>	2

	<p>results</p> <p>at least 11 additional sets of x and V (ie $\Delta x = 20$ mm) ✓✓ [at least 7 additional sets of x and V (ie $\Delta x = 30$ mm) ✓]</p> <p>if both polarities not given then 1 max and allow ecf in c for line and quality; if conductive paper has been reversed deduct both marks here but allow ecf for points</p> <p>significant figures</p> <p>all x to nearest mm and all V (including V_{20} and V_{260}) to nearest mV or to the nearest 0.01 V ✓</p> <p>(tolerate a mixed approach to tabulation of V if meter reading is auto-ranging, ie all given to 3 sf)</p>	<p>2</p> <p>1</p>
c	<p>axes</p> <p>marked V/V (vertical) and x/mm (horizontal) ✓✓</p> <p>deduct $\frac{1}{2}$ for each missing label or separator, rounding down; [bald V (vertical) and x (horizontal) ✓]</p> <p>withhold axis mark if the interval between the numerical values is marked with a frequency of > 5 cm</p> <p>scales</p> <p>points should cover at least half the grid horizontally ✓ and half the grid vertically ✓</p> <p>[a 1 quadrant plot can earn 1 max]</p> <p>(either or both marks may be lost for use of a difficult or non-linear scale)</p> <p>points</p> <p>points from a and b plotted correctly (check at least two for V negative and two for V positive, including any anomalous points) ✓✓✓</p> <p>1 mark is deducted for</p> <p>every item of data (including V_{20} and V_{260}) missing from the graph</p> <p>every point > 1 mm from correct position; a one quadrant plot loses all 3 marks</p> <p>any point poorly marked; tolerate 1 quadrant graph here</p> <p>line</p> <p>two straight-line (ruled) regions of positive gradient; accept these joined (reject crossed lines) by smooth curve of positive increasing gradient; maximum acceptable deviation is 2 mm, adjust criterion if graph poorly-scaled ✓</p> <p>[allow ecf for reversed polarity] (a 1 quadrant plot loses this mark)</p> <p>quality</p> <p>at least 8 points plotted; mark is forfeited for any point > 2 mm from a trend illustrating 2 linear regions of positive gradient [allow ecf for reversed polarity] (judge from graph, providing it is suitably-scaled); 1 quadrant plot loses this mark ✓</p>	<p>2</p> <p>2</p> <p>3</p> <p>1</p> <p>1</p>
	Total	15

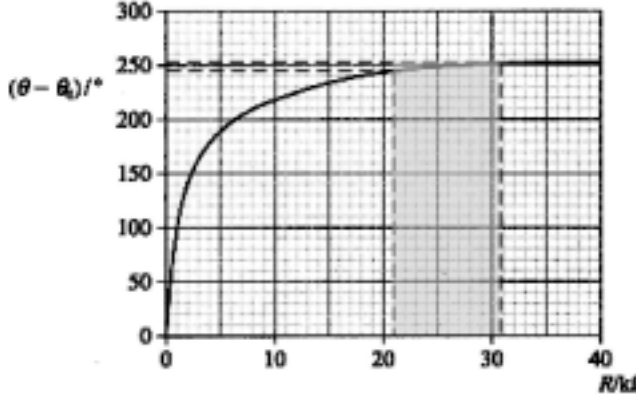
Section B

Question 1			
a	i/ii	evidence from the graph that the line has been extrapolated at each end (tolerate extension of line to the edge of the grid as long as this does not extend into the margins; tolerate if single straight line or curve is drawn) both V read offs correct to 1 mm if directly read off the graph; do not insist on a unit (if scale does not allow direct read off, expect evidence that values of V_0 and/or V_{280} have been calculated using valid gradients of each linear region, values approximately correct by eye) ✓	1
a	iii	x_0 read off correct from graph to 1 mm (tolerate if single straight line or curve is drawn) ✓	1
b	i	valid attempt at gradient calculation and correct transfer of data or $\Delta y/\Delta x = 0$ (if a curve is drawn in error a tangent should be drawn to form the hypotenuse of the triangle) correct transfer of y - and x -step data between graph and calculation $_1$ ✓ (mark is withheld if points used to determine either step > 1 mm from correct position on grid; if tabulated points are used these must lie on the line) y -step and x -step both at least 8 semi-major grid squares $_2$ ✓ [5 by 13 or 13 by 5] (if a poorly-scaled graph is drawn the hypotenuse of the gradient triangle should be extended to meet the 8×8 criteria)	2
b	ii	positive result [allow ecf for reversed polarity], no unit, in the range 0.576 to 0.606 or 2 sf answer in range 0.58 to 0.60 ✓✓ [0.561 to 0.620, 0.57 or 0.61 ✓] (no effect on result if polarity is reversed)	2
Total			

Question 2			
a	i	G will be lower ✓	1
a	ii	$\frac{V_{260}}{V_{20}}$ will be the same (reject 'similar' or 'roughly the same') ✓	1
b		because all values of V are proportionally lower [lower by same percentage or factor] ✓ (reject ' V_0 and V_{280} decrease at the same rate') (award mark if given as explanation to either correct prediction; reject V_{260} and V_{20} are in the same proportion)	1
Total			3

Question 3		
a	read off x) where the gradient of the graph changes [increases/steepens] ✓ (reject 'where the graph starts to curve' or 'where trend changes') (condone 'find x where straight lines meet' but do not credit again in (b))	1
b	<p>either</p> student A's argument is better, consistent with candidate's graph (ie curve between linear regions; reject 1 quadrant plot) ✓ (graph shows) gradient changes over a range of x values ✓ can locate point where width changes by determining the centre of the curving region ✓ more points at this part will help define the shape (of the curve) [improve the detail (of the graph) where the gradient changes] ✓ (reject 'identify/eliminate anomalies') <p>or</p> student B's argument is better, consistent with candidate's graph (two linear regions intersecting at a point; reject 1 quadrant plot) ✓ (idea that) the linear regions intersect at a specific value of x [where straight line regions meet or intersect] ✓ can locate point where width changes (by extrapolating lines) and finding where lines meet [cross] ✓ more points will reduce the impact of random error of the gradients [make gradient/line more reliable [identify/eliminate anomalous results] ✓ (reject 'reduce random error in points' or 'make points/data more reliable')	max 2
	Total	3

Question 4		
i	idea that the wire may not have uniform cross-section [diameter] ✓ (accept 'uneven wire'; reject 'kink' or 'bend' in the wire, or other ideas such as parallax or any other form of human error)	1
ii	repeat the measurement at a different point (on the wire) [with the micrometer in a different direction] ✓ calculate an average result [check/reject any anomalous results] ✓	2
iii	procedure: close jaws and check reading (= zero) ['check for zero error '] ✓ (reject idea of measuring 'known' dimension and checking reading or comparing with readings made using a different instrument)	1
	Total	4

Question 5		
i	± 3 ✓	1
ii	<p>idea that when R_U is approximately $25\text{ k}\Omega$ the gradient of the graph is small [tolerate 'graph is flat/horizontal'] ✓</p> <p>the (small) uncertainty in $\theta - \theta_0$ produces a large uncertainty in R_U [plausible values suggested, eg from $\approx 20\text{ k}\Omega$ to $>40\text{ k}\Omega$] ✓</p> <p>(reject idea that vertical scale is not precise enough)</p> <p>a sketch that conveys how the uncertainty (roughly correct) in $\theta - \theta_0$ produces a correspondingly larger uncertainty in R_U is worth both marks, eg</p>  <p>both marks can be earned for a valid calculation of the uncertainty, or percentage uncertainty, in R_U based on the idea illustrated in the sketch</p>	2
	Total	3

Question 6																										
a	<p>all 5 values of k correctly calculated to ≥ 3 sf ± 0.0001 (accept 2 sf for rows 1 and 2) ✓✓ [1 error = 1 max, all 2 sf = 1 max]</p> <p>(accept reverse working, eg calculation of k for $R = 2.9 \Omega$, $L = 6.6$ cm, then calculation of remaining R values using kL^2; results should all be consistent with values in column 2 of Table 4)</p> <table border="1" data-bbox="416 490 1286 808"> <thead> <tr> <th>L/cm</th> <th>R/Ω</th> <th>R/L^2</th> <th>R/L^2 (2 sf)</th> </tr> </thead> <tbody> <tr> <td>6.6</td> <td>2.9</td> <td>0.0666 [0.067]</td> <td>0.067</td> </tr> <tr> <td>10.6</td> <td>7.6</td> <td>0.0676 [0.068]</td> <td>0.068</td> </tr> <tr> <td>13.8</td> <td>13.0</td> <td>0.0683</td> <td>0.068</td> </tr> <tr> <td>17.8</td> <td>21.6</td> <td>0.0682</td> <td>0.068</td> </tr> <tr> <td>21.4</td> <td>30.4</td> <td>0.0664</td> <td>0.068</td> </tr> </tbody> </table> <p>statement that (all) k values are consistent so theory is correct ✓</p> <p>[for error(s) in k allow 'reject theory' providing largest $k \div$ smallest $k \geq 1.10$; if all R/L^2 shown as 0.07 then 'accept theory' is worth 1 max]</p>	L/cm	R/Ω	R/L^2	R/L^2 (2 sf)	6.6	2.9	0.0666 [0.067]	0.067	10.6	7.6	0.0676 [0.068]	0.068	13.8	13.0	0.0683	0.068	17.8	21.6	0.0682	0.068	21.4	30.4	0.0664	0.068	3
L/cm	R/Ω	R/L^2	R/L^2 (2 sf)																							
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b	<p>correct use of average value of k from at least 3 rows of Table 4 (expect to see 0.0674, 0.067 or 0.07 but condone minor variations) and $R = 3.8 \Omega$ in calculation of L ✓</p> $L = \left(\sqrt{\frac{3.8}{6.74 \times 10^{-2}}} \right) = 7.5(1) \text{ cm } \checkmark$ <p>(accept 2 or 3 sf answers with unit in range 7.4(0) to 7.6(0); no ecf for false average k)</p>	2																								
	Total	5																								

	<p>UMS conversion calculator www.aqa.org.uk/umsconversion</p>	
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