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General Certificate of Education (A-level)
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Physics PHA3/B3/X

Unit 3: Investigative and practical skills in AS Physics

Final

Mark Scheme

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

Section A, Part 1

Question 1				
1	(a)	method:	*d* to 0.01 mm from *nd*, where $n \geq 2$ ✓	**1**
		accuracy:	*d* in range 24.45 mm to 24.55 mm [accept 24.5 mm if raw readings are to 0.01 mm] ✓	**1**
1	(b)(i)	method:	*s* from track or tracks of length or at least 50*s* or Σ50*s*; working must show length(s) to track to nearest mm ✓ (reject ridges in a fixed length method)	**1**
		accuracy:	*s* in range 0.82(0) mm to 0.88(0) mm ✓	**1**
1	(b)(ii)	method and accuracy:	number of ridges (obtained from $\frac{\pi d}{s}$), integer value or deduct 1 mark; result in range 90 to 94 ✓✓ [87 to 97 ✓] (accept rounding up or down as final answer)	**2**
			Total	**6**

Question 2				
2	(a)	results:	(minimum of) six sets of *x* and *R*, *x* range ≥ 25.0 cm; readings of *R* must be valid ✓ (no credit if ruler readings reversed, ie *R* increases as *x* increases)	**1**
		significant figures:	consistent recording of *R* data (all to 0.1 kΩ or 0.10 kΩ but accept a mixture if meter auto-ranges); all *x* data to nearest mm ✓	**1**
2	(b)	scale	vertical scale to cover at least half the grid vertically (10 major grid squares), with appropriate intervals marked with a frequency ≤ 5 cm; if necessary, a false origin, correctly marked, should be used ✓	**1**
		points, line and quality	all tabulated points plotted correctly (check at least one including any that appear anomalous); at least 5 points to 2 mm of a suitable best fit line of negative gradient (accept a <u>smooth</u> curve if points justify this)✓ (no credit if ruler readings reversed)	**1**

2	(c)(i) & (c)(ii)	deduction and explanation:	for expected straight line, only 'linear' circled $_1$✓ **or 0/3** (why not directly proportional) not through the origin [graph has (non-zero) intercept or when *x* doubles *R* does <u>not</u> double etc] $_2$✓ (why not inversely proportional) straight line [constant gradient or as *x* increases [changes] in <u>equal</u> steps, *R* decreases [changes] in <u>equal</u> steps] $_3$✓ (if $y = mx + c$ quoted, allow $_3$✓ but withhold $_2$✓ unless explains that $c \neq 0$) [for curve, only 'none of these' circled $_1$✓ **or 0/3** (why not direct proportion or linear) not a straight line $_2$✓ (why not inverse proportion) suitable qualitative analysis, eg two sets of $R \times x$ evaluated and shown to give inconsistent results $_3$✓] (allow error carried forward for ruler readings reversed: accept direct proportion or linear depending on whether intercept is zero; if false origin is used accept 'linear' only unless algebra has been used to prove otherwise)	**3**
2	(d)(i)	deduction:	value of *R* is increased ✓	**1**
		explanation:	$R = \frac{\rho \times l}{A}\left[\rho = \frac{R \times A}{l}\right]$ quoted ✓ (accept ambiguity in *A*) <u>cross-sectional</u> area is reduced [accept qualitative argument] ✓ (reject 'smaller contact area'; any suggestion that resistivity changes due to smaller width loses this mark)	**1 MAX**
2	(d)(ii)	deduction:	gradient is (numerically) increased [steeper or becomes more negative] ✓	**1**
			Total	**10**

Section A, Part 2

Question 1				
1	(a) (i)/(ii)	accuracy:	*H* and *h* recorded, values sensible, *h* in range 250 mm to 300 mm; if either is not recorded to the nearest mm withhold sf mark in (b) ✓	**1**
1	(b)	tabulation:	x_1 / mm x_2 / mm ✓✓ deduct ½ for each missing label or separator, rounding down	**2**
		results:	6 sets of x_1 and x_2 ✓✓ deduct 1 mark for each missing set; deduct 1 mark if x_1 range < 250 mm	**2**
		significant figures:	all raw values of x_1 and all raw values of x_2 to nearest mm ✓	**1**
1	(c)	axes:	marked x_1/mm (vertical) and x_2/mm (horizontal) ✓✓ deduct ½ for each missing label or separator, rounding down; [bald x_1 (vertical) and x_2 (horizontal) ✓]; no mark if axes are reversed either or both marks may be lost if the interval between the numerical values is marked with a frequency of > 5 cm	**2**
		scales:	points should cover at least half the grid horizontally ✓ and half the grid vertically ✓ (if necessary, a false origin, correctly marked, should be used to meet these criteria; if one or both axes have the origin incorrectly marked only deduct 1 mark; either or both marks may be lost for use of a difficult or non-linear scale)	**2**
		points:	6 points plotted correctly (check at least three, including any anomalous points) ✓✓✓ 1 mark is deducted for every tabulated point missing from the graph and for every point > 1 mm from correct position deduct 1 mark if any point is poorly marked; no credit for false data	**3**
		line:	(ruled) best fit straight line of positive gradient ✓ maximum acceptable deviation from best fit line is 2 mm, adjust criteria if graph is poorly scaled; withhold mark if line is poorly marked	**1**
		quality:	at least 5 points to ± 2 mm of a suitable line of positive constant gradient (judge from graph, adjust criteria if graph is poorly scaled ✓	**1**
			Total	**15**

Section B

Question 1			
1	(i)	valid attempt at gradient calculation and correct transfer of data **or** $_{12}$✓**= 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**
1	(ii)	positive result, no unit, in the range 0.93 to 1.07, or 1.0 ✓✓ [0.85 to 1.15, 0.9 or 1.1 ✓] (reject bland '1')	**2**
		Total	**4**

Question 2			
2	(i)	use of plumb line (condone 'plumb bob') should be mentioned; a reasonable sketch can earn the mark ✓ (reject 'pendulum' but condone 'mass hung from string')	**1**
2	(ii)	(idea that) ball was not at rest when released at top of track [(candidate) may have pushed it/applied force to it] ✓ (reject 'random error', 'the paper moved', 'anomalous result', 'released from lower point', 'not released smoothly', 'pressure applied', 'table was bumped', 'effect of air currents', 'applied <u>more</u> force', 'ball given a higher velocity', 'ball was spinning')	**1**
2	(iii)	reject impact C (can be inferred from absence of 604 in working) $_1$✓ measurement obtained from average of five valid impacts [Σ (readings for A, B, D, E and F)÷5 ; if no written explanation given but working is shown insist on (581+583+583+586+588)÷5] $_2$✓ [accept 'should repeat C $_1$✓and average all six $_2$✓] measurement = 584(.2) (mm) $_3$✓(no ecf if **any** read-offs are incorrect; no credit if this answer is given in (iv)) [if C is not rejected and average of all six impacts is calculated the additional read off should be <u>604</u>; measurement = 587.5 or 588 (mm) $_{123}$✓= 1 MAX]	**3**
2	(iv)	explicit statement or <u>correct</u> working $\left[\frac{588-581}{2}\right]$ to show that uncertainty = ½ range $_4$✓ = (±) 3.5 (mm) $_5$✓ (reject truncation to (±) 4 (mm)) [if C was not rejected in (iii) uncertainty = ½ range $\left[\frac{604-581}{2}\right]$ $_4$✓ = (±) 11.5 (mm) $_5$✓ (reject truncation to (±) 12 (mm))]	**2**
		Total	**7**

Question 3			
3	(a)	voltmeter in parallel with the pencil and ammeter in series with the pencil **or 0/2** ✓ suitable means of varying the pd across the pencil, e.g. variable resistor in series with the pencil or suitable potential divider arrangement expect ASE symbols ✓ (reject attempt to make cell have variable output; labelling as 'variable resistor' but showing wrong symbol loses mark)	**2**
3	(b)	temperature increases [graphite heats up] as <u>current</u> increases (reject reverse argument); accept 'higher pd leads to higher temperature' only if 'higher pd leads to higher current' is also seen $_1$✓ valid comment about Figure 9, eg as current increases, $\frac{I}{V}$ increases [larger change in current is produced by same change in pd; accept numerical values added to axes and two suitable calculations] $_2$✓ (reject idea that $\frac{I}{V}$ [R^{-1}] = gradient of the graph or idea that 'I increases faster than V'; reject 'smaller increase in pd produces bigger increase in current') $\therefore$ ($\frac{I}{V} = \frac{1}{R}$, hence) resistance decreases as <u>temperature</u> increases [graphite heats up] (reject reverse argument) $_3$✓ (if $_1$✓ is earned accept resistance decreases as current increases for $_3$✓)	**3**
3	(c)	reasonable <u>straight</u> best-fit line added to Figure 11 **(or $_{12}$✓=0)**; reject line drawn through origin (vertical intercept should be between <u>1 mm and 4 mm</u> above the origin $_1$✓ correct substitution into gradient calculation using $\Delta I \geq 20$ cm $_2$✓ (only accept y/x method if line is forced through the origin)	**2**
		resistance per metre in range $1.15 \times 10^5\ \Omega(m^{-1})$ to $1.25 \times 10^5\ \Omega(m^{-1})$ [$1.2 \times 10^5\ \Omega(m^{-1})$] $_3$✓	**1**
3	(d)	use of $R = \frac{\rho \times l}{A}$ $\left[\rho = \frac{RA}{l}\right]$ (rearranged to give $\frac{R}{l} = \frac{\rho}{A}$) ✓ substitution of $A = w \times t$ $\left(\text{to give} \frac{R}{l} = \frac{\rho}{w \times t}\right)$ ✓	**2**
3	(e)	measure w with a ruler [(vernier) callipers or travelling microscope] ✓ (reject micrometer)	**1**
		two sensible procedures with technique explained, eg repeat at <u>different</u> positions (reject different sides of strip) <u>and</u> calculate an average result for w [detect and/or reject anomalous readings] ✓ use a protractor or set-square to ensure ruler is perpendicular to edge of strip [use jaws of vernier callipers to ensure measurement is perpendicular to edge of strip] ✓ view from directly above [condone 'at eye level'] to avoid parallax error ✓	**MAX 2**
		Total	**13**

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