A LEVEL

Physics

PHA3/B3/X – Investigative and practical skills in AS Physics

Mark Scheme

2450/2455
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Version 1: Final Mark Scheme

AQA

PHYAB3: Practical and Investigative Skills in AS Physics

Section A Task 1				
1	(a) and (b)	readings:	l_a in range 780 mm to 820 mm and l_b in range 180 mm to 220 mm; both dimensions to nearest mm ✓ I_a and I_b both to mA, both to 0.1 mA, or both to 0.01 mA in range 19(.00) mA to 21(.00) mA; V_a and V_b both to 0.1 V or both to 0.01 V ✓	**2**
1	(c)	method and	r_a and r_b calculated from $\frac{pd}{current \times length}$ ✓ (method mark only; don't penalise for POT error)	**1**
		result:	r_a in range 140 Ωm^{-1} to 170 Ωm^{-1} ✓ (allow other units as long as the value given is appropriate, eg 1.40 Ωcm^{-1}; condone Ω withhold mark for AE in calculation of r_b) max 4sf: note that this is the only **part of Section A where excessive sf are penalised**	**1**
1	(d)	explanation:	(percentage uncertainty in $r_a < r_b$ because) percentage uncertainty in r = <u>sum</u> of the percentage uncertainties in length, pd and current $_1$✓ current: I_a is about the <u>same</u> as I_b (both about 20 mA) so <u>percentage</u> uncertainty <u>in current</u> I_a is <u>same</u> as percentage uncertainty in current I_b $_2$✓ length of wire: l_a is <u>greater</u> than l_b so <u>percentage</u> uncertainty <u>in length</u> l_a is <u>less</u> [smaller] (by about a factor of 4) than the percentage uncertainty in length l_b $_3$✓ pd across wire: V_a is <u>greater</u> than V_b so <u>percentage</u> uncertainty in <u>pd across wire</u> V_a is <u>less</u> [smaller] (by about a factor of 4) than the percentage uncertainty in V_b $_4$✓	**4 MAX 3**

2	(a)	data: range and precision	5 sets of I_1 and V_1 and 5 sets of I_2 and V_2, readings sensible (eg for similar I_2 and I_1 values, $V_1 > V_2$) ✓ (do not penalise for extra sets but insist all tabulated points are plotted) minimum I_1 value ≤ 20 mA, maximum I_2 value ≥ 75 mA; *I* values all to mA, all to 0.1 mA or all to 0.01 mA; *V* values all to 0.1 V or all to 0.01 V ✓ (if precision is inconsistent here <u>and</u> in question 1 do not deduct for a second time)	**2**
2	(b)	graph:	suitable vertical scale: points should cover at least half the grid vertically, ie at least 6 major grid squares (withhold mark for use of a difficult or non-linear scale, wrongly-marked false origin etc) ✓ 10 points plotted correctly, (minimum of) 5 on each line (check at least one on each line, including any anomalous); two <u>ruled</u> best fit lines of positive gradient ✓ (maximum acceptable deviation from best fit lines is 2 mm, adjust criteria if graph is poorly scaled; withhold mark if line(s) is/are poorly marked)	**2**
2	(c)(i)	method for R_X:	evidence of valid attempt at calculation of G_1 based on the gradient of the I_1, V_1 plot [direct calculation of $(G_1)^{-1}$ is acceptable]; R_X, resistance of X, determined from $(G_1)^{-1}$ $_1$✓	**1**
		result for R_X:	result for R_X in range 78 Ω to 86 Ω $_2$✓	**1**
2	(c)(ii)	gradients:	hypotenuse of **each** gradient triangle ≥ 100 mm $_1$✓	**1**
		method for R_Y:	evidence of valid attempt at calculation of G_2, based on the gradient of the I_2, V_2 plot [direct calculation of $(G_2)^{-1}$ is acceptable]; $R_{circuit}$, resistance of (parallel) circuit, determined from $(G_2)^{-1}$; R_Y, resistance of Y, determined from $\left(\frac{1}{R_{circuit}} - \frac{1}{R_X}\right)^{-1}$ $[(G_2 - G_1)^{-1}]$ $_2$✓	**1**
		result for R_Y:	result for R_Y in range 200 Ω to 240 Ω $_3$✓ (unit required for either R_X or R_Y; for POT error here and in (c)(i), eg R_X and R_Y results in range but both × 10^{-3} and not labelled in kΩ, only deduct 1 mark)	**1**
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Section A Task 2				
1	(a)	explanation:	line up plumb line with loop B; move loop T until this is lined up with plumb line ✓	**1**
1	(b)/(c)	tabulation:	*m* / g *y* / mm ✓ full credit for valid alternative units for *m* and *y*	**1**
		results:	9 sets of *m* and *y* ✓✓ deduct 1 mark for each missing set, if *m* is not in the left-hand column of a table with data arranged in rows; deduct this mark if the data is not recorded in a single coherent table, if there is no evidence that <u>mean</u> *y* values have been obtained from repeated readings, eg loading and unloading (condone no repeat for *m* = 900 g), additional mass recorded for *m* (ie values recorded for *m* = 0 to *m* = 800 g) maximum deduction 2 marks; there is no credit for false or invented data	**2**
		significant figures:	all *y* recorded to the nearest mm; if *m* values recorded in kg these must be 3 sf ✓	**1**
1	(d)	axes:	marked *y* /mm (vertical) and *m/* g (horizontal) ✓✓ deduct ½ for each missing label or separator, rounding down; 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 ✓ <u>and</u> half the grid vertically ✓ (if necessary, a false origin should be used to meet these criteria; either or both marks may be lost for use of a difficult or non-linear scale)	**2**
		points:	all tabulated points plotted correctly (check at least three including one from each straight-line section and any anomalous points); 8 or 9 (tabulated and plotted) ✓✓✓ [7 ✓✓, 6 ✓] 1 mark is deducted for each tabulated point that has not been plotted for any plotted point for which the data has not been tabulated for every point > 1 mm from correct position if any point is poorly marked; no credit for false data	**3**
		line:	<u>ruled</u> best fit line of positive gradient from *m* = 100 g to *m* = 300 g and a <u>ruled</u> section of <u>lower</u> positive gradient from *m* = 500 g; these lines must meet at an elbow, otherwise they must be joined by smooth curve with no inflection ✓ 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:	8 points to ± 2mm of a suitable line as described above; if a curve is drawn use a ruler to judge Q from the plotted points, adjusting for any mis-plots; adjust ± 2mm criterion if the graph is poorly scaled ✓	**1**
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Section B			
1	(a)(i) and (a)(ii)	valid attempt at gradient calculation **or** $_{12}$✓ **= 0** (if a curve is drawn in error a tangent or normal should be drawn to form the hypotenuse of the triangle) correct transfer of *y*- and *x*-step data between graph and both calculations $_1$✓ (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) at least one gradient calculation has *y*-step and *x*-step both at least 8 semi-major grid squares [5 by 13 or 13 by 5] $_2$✓ (if a poorly-scaled graph is drawn the hypotenuse of the gradient triangle should be extended to meet the 8 × 8 criteria)	**2**
1	(a)(iii)	$\frac{G_1}{G_2}$, no unit, in range 2.37 to 2.63 or 2.5 ✓✓ [2.25 to 2.75 or 2.3, 2.4, 2.6 or 2.7 ✓] **max 4sf answer: note that this is the only part of Section B where excessive sf are penalised**	**2**
1	(b)(i)	sensible comment about the condition of the central spring at the point when G_1 changes to G_2, eg (the thread becomes tight and) the central spring is placed under tension [is extended / is stretched] $_1$✓ sensible comment about how the condition of the central spring affects the characteristics of the system at the point when G_1 changes to G_2, eg when the central spring comes under tension the system is harder to stretch [stiffness of system is <u>increased</u> / the change in *y* per 100 g [<u>rate of</u> change of *y*] is decreased] $_2$✓ gradient of graph $\propto \frac{1}{\text{stiffness}}$ $_3$✓ (reject gradient = $\frac{1}{\text{stiffness}}$)	**MAX 2**
1	(b)(ii)	<u>extrapolate</u> [<u>extend</u> the line] and read off the *y* [vertical] intercept ✓ (insist on 'extrapolate/extend' and '*y* / vertical intercept or value where line meets *y* axis'; give full credit for a clear annotated diagram showing the line extrapolated to meet the axis and the intercept labelled or for algebraic approach based on intercept = $y - G_1x$ where *y* and *x* are coordinates on the line where the gradient = G_1)	**1**
1	(c)	candidate's graph will be linear [straight line/no change in gradient] <u>of gradient G_1</u> [same gradient as when $m \leq 300$ g] ✓	**1**

2	(a)(i)	when S is closed the resistors R1 and R2 are in parallel $_1$✓ (I_2 is greater than I_1 because) when S is closed) circuit [total / combined] resistance is less [resistance of (combination of) R1 and R2 together is less than the resistance of R1 (by itself)] $_2$✓	5 MAX 3
2	(a)(ii)	idea that (battery) pd [voltage] is shared between the variable resistor and fixed resistor(s) R1 (and R2) [across voltmeter] $_3$✓ *I* × *R* argument pd across variable resistor = current × resistance of variable resistor $_4$✓ (V_1 is greater than V_2 because) when current is greater, pd across variable resistor is greater (so pd across parallel part [voltmeter reading] is less) $_5$✓ [potential divider argument allowed **only when $_3$✓ has been earned** (V_2 is less than V_1 because) the variable resistor has a greater share of the available pd when the introduction of R2 reduces the fixed resistance of the circuit $_{45}$✓]	
2	(b)(i)	mean correctly calculated as 68.9(0) (Ω) ✓ (reject 2sf 69 but allow > 4 sf; do not insist on seeing working)	**1**
	(b)(ii)	working to show uncertainty = half range, result to same dp as mean; for mean = 68.90, uncertainty = 2.95 (Ω) [for mean = 68.9, uncertainty = 3.0] ✓ (reject 1 sf 3 unless 69 given in (b)(i))	**1**
	(b)(iii)	statement (or correct working) to show the resistance at limits of the manufacturer's tolerance are 71.4 Ω and/or 64.6) Ω $_1$✓ **or $_{12}$✓= 0** (from (b)(i) and (b)(ii)) statement (or correct working) to show the resistance (as high as) 71.9 Ω [as low as 65.9 Ω or sum / difference of answers to (b)(i) and (b)(ii)]; a logically consistent statement is also required about whether the resistor is outside the range (expect 'outside' but allow 'yes') $_2$✓	**2**

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3	(a)(i)	position of cross-wires recorded between 94.0 to 110.0 mm, to 0.1 mm ✓	**1**
	(a)(ii)	d in range 12.4 to 12.8 mm ✓ s in range 6.0 to 6.8 mm (reject 6 mm) ✓ the correct unit must appear with at least one of the answers in (a)(i) and (a)(ii), or withhold one mark here	**2**
3	(b)	number of washers found from $\frac{\pi(125+d)}{d}$ (if d is in mm) ✓ 34 [ecf for false d but must be rounded <u>down</u> to an integer] ✓ [$\frac{\pi\left(125+d/2\right)}{d}$ leading to 32 is worth 1 MAX]	**2**
3	(c)(i)	<u>thickness</u> of washer measured with a <u>micrometer</u> [<u>screw gauge</u>, <u>digital</u> vernier callipers: allow (analogue) vernier calliper if the precaution is measure <u>thickness</u> of several washers and find average] ✓ repeat reading <u>in different places</u> and divide by number / find average ✓ [measure multiple thicknesses and divide by number / find average or check for zero error before making measurements or close jaws of micrometer using the <u>ratchet</u> / do not over-tighten the micrometer ✓] (ignore reference to checking calibration)	**2**
		<u>mass</u> of the washer measured (ignored 'weighed with') with a <u>balance</u> (reject 'scales' (digital or otherwise)) ✓ measure (combined) mass of several washers and divide by number of washers / calculate average (mass) [measure mass of <u>different</u> washers and calculate average] ✓ (ecf for 'scales' but no ecf for 'weight') [check for zero error before making measurement / ensure that balance has been tared [zeroed] or ensure that balance is on a horizontal surface ✓] (ignore reference to checking calibration)	**2**
3	(c)(ii)	description of correct algebraic method to determine <u>how</u> the volume of the washer is obtained, eg $\frac{\pi}{4}\times\left(d^2-s^2\right)$ × thickness; if numerical values are suggested for d and s allow ecf from part (a) (reject bland '*cross-sectional area* × *thickness*' or $\frac{\pi}{4}\times(d-s)^2\times thickness$); $density=\frac{mass}{volume}$ ✓	**1**
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