Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2022**

MARK SCHEME

Maximum Mark: 30

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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[Turn over

Question	Answer	Marks
1	**Defining the problem**	
	A is the independent variable and *s* is the dependent variable **or** vary *A* and measure *s*	**1**
	keep *B* and *t* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • pin / rod through hole • supported by a stand • sheet able to oscillate freely • at least one label from copper/sheet, hole, clamp, stand, rod, pin.	**1**
	drawn clamped rule(r) parallel to the direction of the oscillations (by eye) (to measure *s*)	**1**
	use rule(r) to measure lengths to determine *A* **and** *A* = length × breadth	**1**
	use of micrometer to measure *t*	**1**
	Method of Analysis	
	plot a graph of ln *s* against *A* or equivalent	**1**
	relationship valid if a straight line (with *y*-intercept = ln s_0) is produced	**1**
	$K = -\frac{\text{gradient}}{Bt}$ ($K = -\frac{1}{Bt \times \text{gradient}}$ for *A* against ln *s*)	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 use of cushion/sand box <u>in case sheet falls</u> **or** use gloves to protect hands from <u>cuts / sharp edges</u>	
	D2 keep (initial) distance between (copper) sheet and (poles of) magnet <u>constant</u> **or** keep (initial) distance between (copper) sheet and coil(s) <u>constant</u>	
	D3 keep s_0 <u>constant</u>	
	D4 method to ensure s_0 is constant, e.g. initially line up (corner of) plate with fiducial marker / vertical pin to keep s_0 constant	
	D5 method to determine *s* using video camera: • rule(r) in a position to measure *s* in the diagram • video camera shown in diagram or description of use of video camera • playback video recording by frame by frame / slow motion (to measure *s*)	
	D6 repeat measurements of *t* <u>in different positions</u> and <u>average</u> *t*	
	D7 measure *B*/magnetic flux density using a (calibrated) Hall probe	
	D8 additional detail on use of Hall probe, e.g. adjust probe until maximum value **or** measure *B* using Hall probe first in one direction and then in the opposite direction and average	
	D9 drawn method to create a magnetic field perpendicular to the area of the sheet, e.g. pair of magnets/horseshoe magnet/pair of coils connected to a (d.c.) supply	
	D10 repeat experiment for each *A* and average *s*	

Question	Answer	Marks
2(a)	gradient = $\frac{\pi YZd^2}{4\rho}$	**1**
2(b)	$\frac{1}{R}$ / $10^{-3}\,\Omega^{-1}$ 45 or 45.5 37 or 37.0 30 or 30.3 26 or 25.6 21 or 21.3 19 or 18.5	**1**
	Absolute uncertainties in $\frac{1}{R}$ from ± 2 to ± 0.9 or ± 1.	**1**
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	**1**
	Error bars in $\frac{1}{R}$ plotted correctly. All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	**1**
2(c)(ii)	Straight line of best fit drawn. Points must be balanced. Do not accept line from top point to bottom point. Line must pass between (22.0, 30.0) and (23.0, 30.0) **and** (40.5, 65.0) and (42.0, 65.0).	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**

Question	Answer	Marks
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient of worst acceptable line determined with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(d)	0.261 ± 0.003 (mm)	**1**
2(e)(i)	ρ determined using gradient **and** ρ given to two or three significant figures. $\rho = \dfrac{\pi YZd^2}{4 \times \text{gradient}} = \dfrac{\pi \times 22 \times 22 \times \mathbf{(d)}^2}{4 \times \mathbf{(c)(iii)}}$	**1**
	ρ determined using gradient **and** given with correct SI unit (Ω m) **and** correct power of ten	**1**
2(e)(ii)	percentage uncertainty in ρ: $\text{percentage uncertainty} = \left(\dfrac{2 \times \Delta d}{d} + \dfrac{\Delta \text{gradient}}{\text{gradient}} + 0.05 + 0.05 \right) \times 100$ **or** correct substitution for max/min methods $\max \rho = \dfrac{\pi \times (1.05 \times 22) \times (1.05 \times 22) \times (d + \Delta d)^2}{4 \times \text{min gradient}}$ $\min \rho = \dfrac{\pi \times (0.95 \times 22) \times (0.95 \times 22) \times (d - \Delta d)^2}{4 \times \text{max gradient}}$	**1**

Question	Answer	Marks
2(f)	*R* determined to at least two significant figures from **(c)(iii) or (d)** and **(e)(i)** with correct substitution seen. $R = \frac{\text{gradient}}{0.950}$ **or** $R = \frac{\pi YZd^2}{4\rho L} = \frac{\pi \times 22 \times 22 \times \textbf{(d)}^2}{4 \times \textbf{(e)(i)} \times 0.950}$	**1**
	Absolute uncertainty in *R* determined. Method must be consistent with determination of *R* and correct substitution must be seen. for *R* determined using the gradient: $\Delta R = \frac{\Delta\text{gradient}}{\text{gradient}} \times R$ **or** for *R* determined using **(d)** and **(e)(i)**: $\Delta R = \left(\frac{2 \times \Delta d}{d} + \frac{\Delta\rho}{\rho} + 0.05 + 0.05 \right) \times R$ **or** correct substitution for max/min methods: $\max R = \frac{\pi \times (1.05 \times 22) \times (1.05 \times 22) \times (d + \Delta d)^2}{4 \times \min \rho \times 0.950}$ $\min\ R = \frac{\pi \times (0.95 \times 22) \times (0.95 \times 22) \times (d - \Delta d)^2}{4 \times \max\ \rho \times 0.950}$	**1**