Cambridge International AS & A Level

PHYSICS **9702/53**

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

MARK SCHEME

Maximum Mark: 30

Published

This document consists of **9** printed pages.

Question	Answer	Marks
1	**Defining the problem**	
1	A is the independent variable and s is the dependent variable **or** vary A and measure s	**1**
	keep B and t <u>constant</u>	**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 <u>clamped</u> 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 <u>if</u> a straight line (with y-intercept = ln s_0) is produced	**1**
	$$K = -\frac{\text{gradient}}{Bt}$$ $(K = -\dfrac{1}{Bt \times \text{gradient}}$ 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 = $\dfrac{\pi YZd^2}{4\rho}$	**1**
2(b)	<table><tr><td>$\dfrac{1}{R}$ / $10^{-3}\,\Omega^{-1}$</td></tr><tr><td>45 or 45.5</td></tr><tr><td>37 or 37.0</td></tr><tr><td>30 or 30.3</td></tr><tr><td>26 or 25.6</td></tr><tr><td>21 or 21.3</td></tr><tr><td>19 or 18.5</td></tr></table>	**1**
	Absolute uncertainties in $\dfrac{1}{R}$ 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 $\dfrac{1}{R}$ 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. $$\rho = \frac{\pi YZd^2}{4 \times \text{gradient}} = \frac{\pi \times 22 \times 22 \times \textbf{(d)}^2}{4 \times \textbf{(c)(iii)}}$$	1
	ρ determined using gradient **and** given with correct SI unit ($\Omega\,$m) **and** correct power of ten	1
2(e)(ii)	percentage uncertainty in ρ: $$\text{percentage uncertainty} = \left(\frac{2 \times \Delta d}{d} + \frac{\Delta \text{gradient}}{\text{gradient}} + 0.05 + 0.05 \right) \times 100$$ **or** correct substitution for max/min methods $$\max \rho = \frac{\pi \times (1.05 \times 22) \times (1.05 \times 22) \times (d + \Delta d)^2}{4 \times \min \text{ gradient}}$$ $$\min \rho = \frac{\pi \times (0.95 \times 22) \times (0.95 \times 22) \times (d - \Delta d)^2}{4 \times \max \text{ gradient}}$$	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** $$R = \frac{\pi Y Z d^2}{4\rho L} = \frac{\pi \times 22 \times 22 \times \textbf{(d)}^2}{4 \times \textbf{(e)(i)} \times 0.950}$$	**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**