Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2023**

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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Question	Answer	Marks
1	**Defining the problem**.	
	f is the independent variable and *E* is the dependent variable **or** vary *f* and measure *E*	**1**
	keep *V* and *R* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • coils C and D placed with their axes on a straight line • separate workable circuit for coil D • (a.c.) voltmeter or oscilloscope connected across coil D (Do not accept a power supply connected to coil D.)	**1**
	a.c. power supply/signal generator connected to coil C	**1**
	workable circuit for coil C with power supply and (a.c.) voltmeter/oscilloscope in parallel with resistor and coil C	**1**
	method to determine *f*, e.g. read from signal generator or use of oscilloscope	**1**
	Method of Analysis	
	plot a graph of lg *E* against lg *f* or equivalent (e.g. ln *E* against ln *f*)	**1**
	q = gradient	**1**
	$p = \frac{R}{V} \times 10^{y\text{-intercept}}$ (for ln *E* against ln *f*: $p = \frac{R}{V} \times e^{y\text{-intercept}}$)	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 precaution (to prevent burns) from hot coils/hot resistor, e.g. use gloves to handle hot coil/resistor, switch off circuit and wait for hot coil/resistor to cool	
	D2 keep the number of turns on each coil constant	
	D3 keep distance between the coils constant	
	D4 workable circuit diagram to determine R. e.g. circuit with ammeter connected in series and voltmeter in parallel with resistor **or** resistor connected to ohmmeter only	
	D5 determination of resistance R: potential difference across R ÷ current in R **or** use ohmmeter to measure R	
	D6 method to keep distance between the coils constant, e.g. fix/clamp coils to bench	
	D7 method to determine f from oscilloscope, e.g. period T = time-base × horizontal distance **and** $f = 1 / T$	
	D8 method to determine V or E from oscilloscope, e.g. V or E = y-gain × vertical distance	
	D9 method to increase E e.g. use iron core, place coils closer, increase V, decrease R	
	D10 relationship valid if a straight line is produced (passing through log $\left(\frac{pV}{R}\right)$) Do not accept line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $\frac{\sqrt{2g}}{uZ}$

y-intercept = $\frac{\sqrt{2g}}{u}$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td><table><tr><td>$\sqrt{\frac{1}{h}}$ / cm$^{-\frac{1}{2}}$</td></tr><tr><td>0.218 or 0.2182</td></tr><tr><td>0.237 or 0.2370</td></tr><tr><td>0.248 or 0.2485</td></tr><tr><td>0.262 or 0.2617</td></tr><tr><td>0.282 or 0.2817</td></tr><tr><td>0.313 or 0.3131</td></tr></table>Values correct as shown above.</td><td>1</td></tr>
<tr><td>Uncertainties in $\sqrt{\frac{1}{h}}$ from ± 0.001 to ± 0.003.</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(i)</td><td>Six points from (b) plotted correctly.
Must be within half a small square. Diameter of points must be less than half a small square.</td><td>1</td></tr>
<tr><td>Error bars in $\sqrt{\frac{1}{h}}$ plotted correctly.
All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.</td><td>1</td></tr>
</table>

Question	Answer	Marks
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top point to bottom point. Points must be balanced. Line must pass between (605, 0.230) and (615, 0.230) **and** between (845, 0.300) and (855, 0.300)	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**
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 determined of worst acceptable line. 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(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not accept ECF from false origin method.	**1**

Question	Answer	Marks
2(d)(i)	*u* determined using *y*-intercept **and** *u* and *Z* given to 2, 3 or 4 significant figures. $u = \frac{\sqrt{2 \times 981}}{y\text{-intercept}} = \frac{44.29}{\textbf{(c)(iv)}}$	**1**
	Z determined using gradient with method shown **and** *u* and *Z* given with SI units with appropriate powers of ten. $Z = \frac{\sqrt{2 \times 981}}{u \times \text{gradient}} = \frac{44.29}{u \times \textbf{(c)(iii)}}$ **or** $Z = \frac{y\text{-intercept}}{\text{gradient}} = \frac{\textbf{(c)(iv)}}{\textbf{(c)(iii)}}$	**1**
2(d)(ii)	Percentage uncertainty in *Z* with method shown. $\text{percentage uncertainty in } Z = \left(\frac{\Delta y\text{-intercept}}{y\text{-intercept}} + \frac{\Delta \text{gradient}}{\text{gradient}} \right) \times 100$ **or** Correct substitution for Δu and $\text{percentage uncertainty in } Z = \left(\frac{\Delta u}{u} + \frac{\Delta \text{gradient}}{\text{gradient}} \right) \times 100$ **or** Correct substitution for max/min methods.	**1**

Question	Answer	Marks
2(e)	*M* determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution. $M = \dfrac{\left(\dfrac{1}{\sqrt{25}} - y\text{-intercept}\right)}{\text{gradient}}$ **or** $M = \dfrac{uZ}{\sqrt{2gh}} - Z = \dfrac{uZ}{221.5} - Z$	**1**