CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

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**	
	t is the independent variable and *s* is the dependent variable **or** vary *t* and measure *s*	**1**
	keep *k* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • spring connected to magnet • vertical rule parallel to spring to determine *s* • rule held in position by a stand • stand resting on the bench • rule labelled and at least one other label from stand, clamp, card, (magnetic) sheet, (cylindrical) magnet, spring	**1**
	s = (new) length/position of spring – original length/position of spring	**1**
	use a micrometer to measure *t*	**1**
	measure *B* using a (calibrated) Hall probe **and** rotate probe until maximum value **or** measure *B* using Hall probe first in one direction, then in the opposite direction and average	**1**

Question	Answer	Marks
1	**Method of Analysis**	
	plot a graph of s against $\frac{1}{t}$ or equivalent (allow lg s against lg t)	**1**
	relationship valid <u>if</u> a straight line that passes through the origin is produced (for lg s against lg t: relationship valid <u>if</u> a straight line with gradient -1)	**1**
	$Z = \frac{k}{ALB} \times$ gradient (for lg s against lg t: $Z = \frac{k \times 10^{y\text{-intercept}}}{ALB}$)	**1**

Question	Answer		Marks
1	**Additional detail including safety considerations**		**6**
	D1	precaution related to spring and/or magnet hitting eyes, e.g. use of goggles/use of safety screen around experiment	
	D2	keep *A*, *L* and *B* constant	
	D3	use a rule to measure *L*	
	D4	micrometer/calipers to measure diameter *d* of the magnet **and** $A = \pi d^2 / 4$	
	D5	description of method to determine *k*, e.g. add mass to spring **and** $k = mg /$ extension **or** use newton meter to measure force applied to spring **and** *k* = force / extension **or** take several readings of force and extension, plot a force–extension graph **and** *k* = gradient	
	D6	(magnetic) sheet clamped to bench	
	D7	use pointer(s)/marker(s) on the spring to read off values from the rule	
	D8	method to use video recorder and replay to determine maximum length of the spring **or** increase *s* or force gradually/slowly until magnet (just) leaves the card	
	D9	repeat measurements of *t* in different positions on the card **and** average *t* **or** repeat measurements of *s* for each value of *t* **and** average *s*	
	D10	method to check that the spring has not exceeded the elastic limit	
	D11	use of non-magnetic stand or named non-magnetic material for stand, e.g. wood	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = n
y-intercept = lg $\frac{2}{C}$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td><table><tr><th>lg (L / cm)</th><th>lg (T / 10^{-5} s)</th></tr><tr><td>1.73 or 1.732</td><td>1.38 or 1.380 ± 0.02</td></tr><tr><td>1.85 or 1.845</td><td>1.51 or 1.505 ± 0.01</td></tr><tr><td>1.93 or 1.934</td><td>1.59 or 1.591 ± 0.01</td></tr><tr><td>2.033 or 2.0334</td><td>1.69 or 1.690 ± 0.02</td></tr><tr><td>2.146 or 2.1461</td><td>1.81 or 1.806 ± 0.01</td></tr><tr><td>2.223 or 2.2227</td><td>1.87 or 1.869 ± 0.01</td></tr></table>Values of lg (L / cm) and lg (T / 10^{-5} s) correct as shown above.</td><td>1</td></tr>
<tr><td>Uncertainties in lg (T / 10^{-5} s) correct as shown above.</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 lg T 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. Line must pass between (1.780, 1.45) and (1.800, 1.45) **and** between (2.085, 1.75) and (2.100, 1.75)	**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 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(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *x* 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)	Value of n determined using gradient (n = gradient) **and** C given to 2 or 3 significant figures.	**1**
	Value of C determined using y-intercept with method shown. $C = \frac{2}{10^{y\text{-intercept}}}$	**1**
	Absolute uncertainties in n and C. uncertainty in n = uncertainty in gradient **and** $\Delta C = C - \frac{2}{10^{\text{worst y-intercept}}}$ **or** $\Delta C = \frac{\frac{2}{10^{\text{min worst } y\text{-intercept}}} - \frac{2}{10^{\text{max worst } y\text{-intercept}}}}{2}$ Clear method must be shown with ΔC correctly evaluated.	**1**
2(e)	Value of L determined (non-zero) to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)** with correct substitution **and** correct power of ten. Units of T and either C or y-intercept must be consistent. $\log L = \frac{\log T - \log \frac{2}{C}}{n} = \frac{\log 10 - y\text{-intercept}}{n}$ $L = 10^{\frac{\log 10 - y\text{-intercept}}{n}}$ **or** $L = \sqrt[n]{\frac{TC}{2}}$	**1**