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PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2024**

MARK SCHEME

Maximum Mark: 30

Published

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This document consists of **11** printed pages.

Question	Answer	Marks
1	**Defining the problem**	
	s is the independent variable and *v* is the dependent variable **or** vary *s* and measure *v*	**1**
	keep *D* <u>constant</u>	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • light gate positioned at P • light gate connected to timer / data logger • labels for light gate **and** P **and** data logger / timer **and** at least one other label from block, magnet(s), trolley, *s* and *D*	**1**
	measure *D* with a rule(r) **and** measure *L* with a rule(r) or calipers	**1**
	description to determine *v* at P, e.g. (measure length of) card to interrupt beam	**1**
	method to measure *s*, e.g. use calipers	**1**

Question	Answer	Marks
1	**Method of Analysis**	
	plot a graph of v^2 against $\frac{1}{s^4}$ or equivalent (e.g. $\frac{1}{s^4}$ against v^2) Do not accept logarithms.	**1**
	$K = \frac{m \times \text{gradient}}{2DA^2B^2L^2}$ (or $K = \frac{m}{2DA^2B^2L^2 \times \text{gradient}}$ for $\frac{1}{s^4}$ against v^2)	**1**
	$Q = -\frac{m \times y\text{-intercept}}{2D}$ (or $Q = KA^2B^2L^2 \times y\text{-intercept}$ or $Q = \frac{m \times y\text{-intercept}}{2D \times \text{gradient}}$ for $\frac{1}{s^4}$ against v^2)	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 method to <u>stop</u> the trolley (after passing point P), e.g. labelled block / buffer / cushion drawn after P **or** place a block / buffer / cushion after P to <u>stop</u> the trolley	
	D2 keep L, A, m and B <u>constant</u>	
	D3 use micrometer / calipers to measure diameter (d) of the magnet **and** $A = \frac{\pi d^2}{4}$	
	D4 method to secure block to bench, e.g. clamp block to bench or (heavy) mass on top of block **or** method to secure magnets, e.g. use glue to stick magnets to trolley / block	
	D5 method to increase the accuracy of measuring s or D, e.g. use a marker to left of the trolley	
	D6 measure B using a (calibrated) Hall probe **and** adjust / rotate probe until <u>maximum</u> value **or** measure B using Hall probe first in one direction, then in the opposite direction and average	
	D7 use a (top-pan) balance to measure m	
	D8 use of strong magnets to increase v	
	D9 repeat measurements of v for each value of s **and** average v	
	D10 relationship valid <u>if</u> a straight line is produced (passing through $\left(-\frac{2DQ}{m}\right)$) Do not accept line passing through the origin.	

Question	Answer	Marks
2(a)	gradient = $\frac{3}{3E - E_s}$ y-intercept = $\frac{2Z}{3E - E_s}$	**1**
2(b)	$\frac{1}{I}$ / A^{-1} 5150 or 5155 5560 or 5556 5810 or 5814 6250 6670 or 6667 6940 or 6944 Values correct as shown above.	**1**
	Uncertainties in $\frac{1}{I}$ from ±50 or ±60 to ±90 or ±100.	**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 $\frac{1}{I}$ 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**

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 (1.63, 5400) and (1.67, 5400) **and** between (2.58, 6800) and (2.62, 6800).	**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)(i)	*E* determined using gradient **and** *E* and *Z* given to 2 or 3 or 4 significant figures. $E = \frac{1}{3}\left(\frac{3}{\text{gradient}} + E_s\right) = \frac{3 + \text{gradient} \times E_s}{3 \times \text{gradient}} = \frac{1}{\text{gradient}} + \frac{E_s}{3}$ $E = \frac{1}{\text{gradient}} + 0.733$	**1**
	Z determined using *y*-intercept **and** *E* and *Z* given with SI units with correct powers of ten. $Z = \frac{(3E - E_s) \times y\text{-intercept}}{2}$ **or** $Z = \frac{3 \times y\text{-intercept}}{2 \times \text{gradient}}$ Unit of *E*: V Unit of *Z*: Ω	**1**
2(d)(ii)	Absolute uncertainty in *E* with method shown. $\text{uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} \times \frac{1}{\text{gradient}}\right) + \frac{0.05}{3}$ **or** correct substitution for max/min methods.	**1**

Question	Answer	Marks
2(e)	Value of *R* determined to a minimum of two significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution **and** correct use of power of ten. $R = \dfrac{\dfrac{1}{250 \times 10^{-6}} - y\text{-intercept}}{\text{gradient}}$ **or** $R = \dfrac{1}{\text{gradient} \times 250 \times 10^{-6}} - \dfrac{2Z}{3}$ **or** $R = \dfrac{3E - 2.2}{3 \times 250 \times 10^{-6}} - \dfrac{2Z}{3}$	1