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PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2024**

MARK SCHEME

Maximum Mark: 30

Published

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

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

Question	Answer	Marks
1	**Defining the problem**	
	L is the independent variable and f is the dependent variable, or vary L and measure f.	**1**
	Keep ρ <u>constant</u>	**1**
	Methods of data collection	
	Labelled diagram of workable experiment including: • rod supported by string / elastic bands from a clamp • clamp attached to stand, with stand on bench • two labels from stand, clamp, hammer, microphone, rod, string.	**1**
	Diagram showing labelled microphone connected to labelled oscilloscope.	**1**
	Method to measure L, e.g. use a metre rule	**1**
	Method to measure mass (m) (of metal rod), e.g. use a (top-pan) balance	**1**
	Method of Analysis	
	Plots a graph of log f against log L or equivalent e.g. log f against log $\frac{1}{L}$	**1**
	$n = -$ gradient (for log f against log $\frac{1}{L}$: n = gradient)	**1**
	$E = 4\rho \times 10^{2\times y\text{-intercept}}$ (for lg f vs lg $\frac{1}{L}$: $E = 4\rho \times 10^{2\times y\text{-intercept}}$) (for ln f against ln L; $E = 4\rho \times e^{2\times y\text{-intercept}}$)	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations** Any **six** from:	**6**
	D1 Precaution linked to falling rod, e.g. sand tray / cushion (in case rod falls) OR gently hit rod prevent rod falling	
	D2 Method to determine area of rod (A) e.g. measure diameter (d) of rod using a micrometer / calipers	
	D3 Repeat measurements of diameter along the length of rod / around the rod and average diameter	
	D4 Method to determine ρ from experimental method, e.g. $\rho = \frac{m}{AL}$ **and** $A = \frac{\pi d^2}{4}$ **or** $\rho = \frac{4m}{\pi d^2 L}$ **or** $r = \frac{d}{2}$ **and** $\rho = \frac{m}{\pi r^2 L}$	
	D5 Perform experiment in a quiet room	
	D6 Reasoned method to prevent rod hitting microphone, e.g. have a gap between rod and microphone / gently hit rod **or** method to obtain measurable signal from the microphone, e.g. use a cone to increase the sound detected by the microphone	
	D7 Method to determine frequency from oscilloscope, e.g. T = time-base × (horizontal) length (of one wave) **and** $f = 1/T$	
	D8 Method to reduce uncertainties e.g. use large values of L to reduce (percentage) uncertainty in L **or** adjust time-base to display as few waves as possible or Z waves on oscilloscope and divide time by Z **or** wait for the wave(form) / frequency to stabilise (and reach resonance)	
	D9 Repeat measurements of f for each value of L **and** average f	

Question	Answer	Marks
1	D10 Relationship is valid <u>if</u> a straight line is produced (passing through $\log\left(\frac{1}{2}\sqrt{\frac{E}{\rho}}\right)$ OR $\frac{1}{2}\log\left(\sqrt{\frac{E}{4\rho}}\right)$). Do not accept passing through the origin.	

Question	Answer	Marks
2(a)	Gradient = $\frac{3}{E}$ y-intercept = $\frac{4Z}{E}$	**1**
2(b)	$\frac{1}{I}$ / A^{-1} 4440 or 4444 5410 or 5405 6250 or 6250 7140 or 7143 8000 or 8000 8700 or 8696	**1**
	Uncertainties in $\frac{1}{I}$ From ± 90–110 to ± 360–400	**1**

Question	Answer	Marks
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**
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top plot to bottom plot. Points must be balanced. Line must pass between (1.8, 5000) and (2.1, 5000) **and** between (7.2, 8500) and (7.5, 8500)	**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)	**1**

Question	Answer	Marks
2(d)(i)	*E* determined using gradient **and** *E* and *Z* given to 2, 3 or 4 sf. $E = \frac{3}{\text{gradient}}$	**1**
	Z determined using *y*-intercept **and** *E* and *Z* given with SI units with correct powers of ten $Z = \frac{E \times y\text{-intercept}}{4}$ **or** $Z = \frac{3 \times y\text{-intercept}}{4 \times \text{gradient}}$ Unit of *E*: V or A Ω Unit of *Z*: Ω	**1**
2(d)(ii)	Percentage uncertainty in *Z* with method shown. $\%\text{uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + \frac{\Delta y\text{-intercept}}{y\text{-intercept}}\right)$ **or** Correct substitution for max/min methods.	**1**
2(e)	*R* determined to a minimum of 2sf from **(c)(iii)** and **(c)(iv) or (d)(i)** with correct substitution **and** correct powers of ten. 0.1 mA = 0.1 × 10^{-3} A **and** $R = \frac{\frac{1}{0.10 \times 10^{-3}} - y\text{-intercept}}{\text{gradient}}$ **or** $R = \frac{E}{3 \times 0.10 \times 10^{-3}} - \frac{4Z}{3}$	**1**