Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2021**

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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[Turn over

Annotations

✓	Correct point Method of analysis marks in **Question 1**
$✓_{1–10}$	Additional detail marks in **Question 1**
X	Incorrect point
^	Omission
BOD	Benefit of the doubt
NBOD	No benefit of the doubt given
ECF	Error carried forward
P	Defining the problem marks in **Question 1** Power of ten error in **Question 2**
M0	Methods of data collection marks in **Question 1**
SF	Incorrect number of significant figures

Question	Answer	Marks
1	**Defining the problem**	
	diameter/*d* is the independent variable and frequency/*f* is the dependent variable **or** vary *d* and measure *f*	**1**
	keep *L* constant or length (of tube) constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • tube supported • (loud)speaker positioned in line with the tube • (loud)speaker labelled	**1**
	labelled microphone, positioned outside tube in line with tube, connected to labelled oscilloscope or correct circuit symbol	**1**
	adjust/change frequency until maximum amplitude detected	**1**
	use calipers to measure *d*	**1**

Question	Answer	Marks
1	**Method of analysis**	
	plot a graph of $\frac{1}{f}$ against d **or** d against $\frac{1}{f}$ (Do not accept logarithmic graphs.)	**1**
	for $\frac{1}{f}$ against d $v = \frac{2L}{y\text{-intercept}}$ **or** for d against $\frac{1}{f}$ v = gradient $\times$ k **or** $v = -\frac{\text{gradient} \times 2L}{y\text{-intercept}}$	**1**
	for $\frac{1}{f}$ against d k = gradient $\times$ v **or** $k = \frac{\text{gradient} \times 2L}{y\text{-intercept}}$ **or** for d against $\frac{1}{f}$ $k = -\frac{2L}{y\text{-intercept}}$	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 wear ear defenders (to prevent damage to hearing/to avoid loud sounds) **or** use a low volume to prevent damage to hearing/to avoid loud sounds	
	D2 use a rule to measure *L*	
	D3 increase frequency from a low frequency to the first maximum amplitude	
	D4 method to determine *f* at maximum amplitude, e.g. increase frequency to *f*, then continue increasing frequency, and then decrease frequency until value of *f* determined	
	D5 method to determine period from oscilloscope, e.g. no. of divisions × time-base	
	D6 for frequency/time period determined by oscilloscope, $f = 1 / T$	
	D7 repeat measurements of *d* and average in different directions/positions or along the tube	
	D8 perform experiment in a quiet room	
	D9 signal generator connected to (loud)speaker in diagram	
	D10 relationship valid if a straight line produced (Do not accept through the origin.)	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $-\frac{t}{C}$
y-intercept = ln E</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td>
<table>
<tr><th>$(R_1 + R_2)$ / kΩ</th><th>$\frac{1}{R_1 + R_2}$ / 10^{-6} Ω</th></tr>
<tr><td>55 (± 3)</td><td>18 or 18.2 ± 0.9</td></tr>
<tr><td>69 (± 3 or 4)</td><td>14 or 14.5 ± 0.7</td></tr>
<tr><td>90 (± 4 or 5)</td><td>11 or 11.1 ± 0.6</td></tr>
<tr><td>80 (± 4)</td><td>13 or 12.5 ± 0.6</td></tr>
<tr><td>101 (± 5)</td><td>9.9 or 9.90 or 9.901 ± 0.5</td></tr>
<tr><td>115 (± 6)</td><td>8.7 or 8.70 or 8.696 ± 0.4</td></tr>
</table>
Values of $(R_1 + R_2)$ and $\frac{1}{R_1 + R_2}$ correct as shown above.</td><td>1</td></tr>
<tr><td>Absolute uncertainties in $\frac{1}{R_1 + R_2}$ from ± 0.9 or ± 1 to ± 0.4 or ± 0.5.</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(i)</td><td>Six points plotted correctly.
Must be accurate to 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 $\frac{1}{R_1 + R_2}$ plotted correctly.
All error bars must 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)	Line of best fit drawn. Points must be balanced. Do not accept line from top point to bottom point. Line must pass between (10.2, 1.10) and (10.8, 1.10) **and** between (16.7, 0.40) and (17.2, 0.40).	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all error bars). All error bars must be plotted.	**1**
2(c)(iii)	Negative gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be at least half the length of the drawn line.	**1**
	Gradient of worst acceptable line determined. 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 point on line into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution of point on line 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**
2(d)(i)	*C* determined using gradient **and** *C* and *E* both given to two or three significant figures. $C = -\frac{t}{\text{gradient}} = -\frac{60}{\textbf{(c)(iii)}}$	**1**
	E determined using *y*-intercept **and** *C* and *E* both given with correct SI unit. $E = \text{e}^{y\text{-intercept}}$ unit of *C*: F **or** C V^{-1} **or** s Ω^{-1} unit of *E*: V	**1**

Question	Answer	Marks
2(d)(ii)	Percentage uncertainty determined with method shown. $\text{percentage uncertainty} = \left(\frac{1}{60} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ Clear substitution must be shown for maximum/minimum methods.	**1**
2(e)	(R_1 + R_2) determined to at least two significant figures from **(d)(i) or (c)(iii)** and **(c)(iv)** with correct substitution including signs <u>and</u> correct power of ten(s). Do not accept ECF for POT from **(c)(iii)**, **(c)(iv)** or **(d)**. $(R_1 + R_2) = -\frac{t}{C} \times \frac{1}{\ln\frac{V}{E}} = -\frac{60}{C} \times \frac{1}{\ln V - \ln E}$ **or** $(R_1 + R_2) = \frac{\text{gradient}}{\ln 5.0 - y\text{-intercept}} = \frac{\textbf{(c)(iii)}}{1.61 - \textbf{(c)(iv)}}$	**1**