



Cambridge International AS & A Level

PHYSICS

9702/51

Paper 5 Planning, Analysis and Evaluation

October/November 2021

MARK SCHEME

Maximum Mark: 30

<p>Published</p>

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

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

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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 <u>constant</u> or length (of tube) <u>constant</u>	1
	Methods of data collection	
	labelled diagram of workable experiment including: <ul style="list-style-type: none"> • tube supported • (loud)speaker positioned in line with the tube • (loud)<u>speaker</u> labelled 	1
	labelled microphone, positioned outside tube in line with tube, connected to labelled oscilloscope or correct circuit symbol	1
	adjust/change frequency until <u>maximum</u> amplitude detected	1
	use calipers to measure d	1

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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
	<div> <div>for $\frac{1}{f}$ against d</div> <hr/> $v = \frac{2L}{\text{y-intercept}}$ </div> <div>or</div> <div> <div>for d against $\frac{1}{f}$</div> <hr/> $v = \text{gradient} \times k$ <div>or</div> $v = -\frac{\text{gradient} \times 2L}{\text{y-intercept}}$ </div>	1
	<div> <div>for $\frac{1}{f}$ against d</div> <hr/> $k = \text{gradient} \times v$ <div>or</div> $k = \frac{\text{gradient} \times 2L}{\text{y-intercept}}$ </div> <div>or</div> <div> <div>for d against $\frac{1}{f}$</div> <hr/> $k = -\frac{2L}{\text{y-intercept}}$ </div>	1

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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 <u>to prevent damage to hearing/to avoid loud sounds</u>	
	D2 use a rule to measure L	
	D3 increase frequency from a <u>low</u> frequency to the <u>first</u> 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 \times time-base	
	D6 for frequency/time period determined by oscilloscope, $f = 1 / T$	
	D7 repeat measurements of d and average in <u>different</u> directions/positions or <u>along the tube</u>	
	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.)	

Question	Answer		Marks														
2(a)	gradient = $-\frac{t}{C}$ y-intercept = $\ln E$		1														
2(b)	<table><tr><td>$(R_1 + R_2) / \text{k}\Omega$</td><td>$\frac{1}{R_1 + R_2} / 10^{-6} \Omega$</td></tr><tr><td>55 ($\pm 3$)</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>		$(R_1 + R_2) / \text{k}\Omega$	$\frac{1}{R_1 + R_2} / 10^{-6} \Omega$	55 (± 3)	18 or 18.2 ± 0.9	69 (± 3 or 4)	14 or 14.5 ± 0.7	90 (± 4 or 5)	11 or 11.1 ± 0.6	80 (± 4)	13 or 12.5 ± 0.6	101 (± 5)	9.9 or 9.90 or 9.901 ± 0.5	115 (± 6)	8.7 or 8.70 or 8.696 ± 0.4	1
	$(R_1 + R_2) / \text{k}\Omega$	$\frac{1}{R_1 + R_2} / 10^{-6} \Omega$															
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	Values of $(R_1 + R_2)$ and $\frac{1}{R_1 + R_2}$ correct as shown above.																
	Absolute uncertainties in $\frac{1}{R_1 + R_2}$ from ± 0.9 or ± 1 to ± 0.4 or ± 0.5 .		1														
2(c)(i)	Six points plotted correctly. Must be accurate to half a small square. Diameter of points must be less than half a small square.		1														
	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.		1														

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)	<u>Negative</u> 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 = $\frac{1}{2}$ (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 = $\frac{1}{2}$ (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. $C = -\frac{t}{\text{gradient}} = -\frac{60}{\text{(c)(iii)}}$	1
	E determined using y-intercept and C and E both given with correct SI unit. $E = e^{y\text{-intercept}}$ unit of C: F or C V ⁻¹ or s Ω ⁻¹ unit of E: V	1

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Question	Answer	Marks
2(d)(ii)	<p>Percentage uncertainty determined with method shown.</p> $\text{percentage uncertainty} = \left(\frac{1}{60} + \frac{\Delta \text{gradient}}{\text{gradient}} \right) \times 100$ <p>Clear substitution must be shown for maximum/minimum methods.</p>	1
2(e)	<p>$(R_1 + R_2)$ 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).</p> $(R_1 + R_2) = -\frac{t}{C} \times \frac{1}{\ln \frac{V}{E}} = -\frac{60}{C} \times \frac{1}{\ln V - \ln E}$ <p>or</p> $(R_1 + R_2) = \frac{\text{gradient}}{\ln 5.0 - y\text{-intercept}} = \frac{\text{(c)(iii)}}{1.61 - \text{(c)(iv)}}$	1