
PHYSICS

9702/51

Paper 5 Planning, Analysis and Evaluation

October/November 2016

MARK SCHEME

Maximum Mark: 30

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	51

Question	Answer	Marks
1	Defining the problem	
	B is the independent variable and v is the dependent variable, or vary B measure v .	1
	Keep starting position of magnet constant/magnet always released from rest.	1
	Methods of data collection	
	Labelled diagram showing a magnet and the vertical copper tube supported.	1
	Method to ensure that copper tube is vertical, e.g. set square, spirit level, plumb line.	1
	Method to determine time at <u>bottom</u> of tube e.g. use of light gate(s)/motion sensor attached to timer/datalogger/computer or distance between two fixed marks at bottom of tube and stopwatch. Do not allow time over length of tube.	1
	Method to <u>measure B</u> , e.g. Hall probe.	1
	Method of analysis	
	Plot a graph of $\ln v$ against B .	1
	$\lambda = -\text{gradient}$	1
	$v_0 = e^{\text{y-intercept}}$	1

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Question	Answer	Marks
	Additional detail including safety considerations	6
	1. Keep mass of magnet constant. 2. Measurement of an appropriate length to determine v at bottom of tube, e.g. use ruler to measure distance between light gates/length of magnet/between two fixed marks. 3. $v = d / t$ for appropriate lengths (not length of tube) 4. Adjust Hall probe until maximum reading obtained/perpendicular to field/pole or Use Hall probe to take readings for both poles and average. 5. Method to calibrate Hall probe using a known field. 6. Safety precaution linked to falling magnets/use sand tray/cushion to soften fall. 7. Repeat experiment with magnets reversed and average or Repeat v (or t) for same B and average. 8. $\ln v = -\lambda B + \ln v_0$ 9. Relationship is valid if the graph is a straight line. 10. Method to vary B, e.g. re-magnetise in a coil.	

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks												
2 (a)	gradient = $\frac{1}{YE}$ y-intercept = $\frac{1}{E}$	1												
(b)	<table border="1"><tr><td>2.7 or 2.70</td><td>0.833 or 0.8333</td></tr><tr><td>1.4 or 1.35</td><td>0.513 or 0.5128</td></tr><tr><td>0.90 or 0.900</td><td>0.426 or 0.4255</td></tr><tr><td>0.68 or 0.675</td><td>0.364 or 0.3636</td></tr><tr><td>0.54 or 0.540</td><td>0.345 or 0.3448</td></tr><tr><td>0.45 or 0.450</td><td>0.328 or 0.3279</td></tr></table> All first column correct. Allow a mixture of significant figures. All second column correct. Allow a mixture of significant figures. Uncertainties in X from ± 0.4 to ± 0.07 (± 0.1). Allow more than one significant figure.	2.7 or 2.70	0.833 or 0.8333	1.4 or 1.35	0.513 or 0.5128	0.90 or 0.900	0.426 or 0.4255	0.68 or 0.675	0.364 or 0.3636	0.54 or 0.540	0.345 or 0.3448	0.45 or 0.450	0.328 or 0.3279	1 1 1
2.7 or 2.70	0.833 or 0.8333													
1.4 or 1.35	0.513 or 0.5128													
0.90 or 0.900	0.426 or 0.4255													
0.68 or 0.675	0.364 or 0.3636													
0.54 or 0.540	0.345 or 0.3448													
0.45 or 0.450	0.328 or 0.3279													
(c) (i)	Six points plotted correctly. Must be within half a small square. No “blobs”.	1												
	All error bars in X plotted correctly. All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.	1												
(ii)	Line of best fit drawn. Line must not be drawn from top point to bottom point. The lower end of line should pass between (0.95, 0.45) and (1.1, 0.45) and upper end of line should pass between (2.10, 0.70) and (2.25, 0.70).	1												
	Worst acceptable line drawn correctly. Steepest or shallowest possible line that passes through <u>all</u> the error bars. Mark scored only if all error bars are plotted.	1												
(iii)	Gradient determined with a triangle that is at least half the length of the drawn line. Read-offs must be accurate to half a small square.	1												
	Method of determining absolute uncertainty. uncertainty = gradient of line of best fit – gradient of worst acceptable line <i>or</i> uncertainty = $\frac{1}{2}$ (steepest worst line gradient – shallowest worst line gradient)	1												
(iv)	y-intercept determined correctly by substitution into $y = mx + c$. Read-offs must be accurate to half a small square.	1												

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Question	Answer	Marks
	Method of determining absolute uncertainty. 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) No ECF from false origin method.	1
(d) (i)	$E = 1/\text{y-intercept}$ <u>and</u> given to 2 or 3 s.f.	1
	$Y = \frac{1}{E \times \text{gradient}} \text{ or } \frac{y - \text{intercept}}{\text{gradient}}$ Y in the range $(0.90 \text{ to } 1.20) \times 10^{-3} \text{ F}$. Appropriate unit required. Correct substitution of numbers must be seen.	1
(ii)	Percentage uncertainty in Y $= \left(\frac{\Delta m}{m} + \frac{\Delta c}{c} \right) \times 100 \text{ or}$ $= \left(\frac{\Delta m}{m} + \frac{\Delta E}{E} \right) \times 100 \text{ or}$ $= \frac{\Delta Y}{Y} \times 100$ Maximum/minimum methods: $\text{max } Y = \frac{1}{\text{min } E \times \text{min gradient}} = \frac{\text{max } y - \text{intercept}}{\text{min gradient}}$ $\text{min } Y = \frac{1}{\text{max } E \times \text{max gradient}} = \frac{\text{min } y - \text{intercept}}{\text{max gradient}}$	1

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	Cambridge International AS/A Level – October/November 2016	9702	52

Question	Answer	Marks
1	Defining the problem	
	p is the independent variable and B is the dependent variable, or vary p and measure B .	1
	Keep the current/ I (in the electromagnet) constant.	1
	Methods of data collection	
	Labelled diagram showing Hall probe correctly positioned (along p) <u>and</u> ruler correctly positioned <u>and</u> either Hall probe or rule supported.	1
	Correct circuit diagram to include <u>d.c.</u> power supply in series with coil and ammeter. Must be a workable circuit diagram to measure current through the coil.	1
	Measure p with ruler.	1
	Method to determine an accurate value of p . Examples include: Height of P above bench – height of electromagnet Height of P measured from ruler across the top of the electromagnet	1
	Method of analysis	
	Plot a graph of $\ln B$ against p .	1
	$\alpha = -\text{gradient}$	1
	$k = \frac{e^{y\text{-intercept}}}{NI}$	1

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
	Additional detail including safety considerations	6
	1. Keep the number of turns/N constant. 2. Use large number of turns/current (to increase B). 3. Avoid overheating the coil/do not touch hot coil. 4. Use of variable resistor to keep ammeter reading constant. 5. <u>Method</u> to ensure that Hall probe is equidistant from the poles, e.g. determine centre of electromagnet and use of plumb line/ruler <u>and</u> spirit level/set square. 6. Adjust Hall probe until maximum reading obtained/perpendicular to field. 7. <u>Repeat</u> each experiment for the same value of p and <u>reverse</u> the current/Hall probe and <u>average</u> 8. $\ln B = -\alpha p + \ln kNI$ 9. Relationship is valid if the graph is a straight line. 10. Calibrate Hall probe <u>using a known field</u>.	

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks												
2 (a)	gradient = q y -intercept = $\lg p$	1												
(b)	<table><tr><td>2.80 or 2.799 or 2.7993</td><td>0.28 or 0.279</td></tr><tr><td>2.79 or 2.792 or 2.7924</td><td>0.30 or 0.301</td></tr><tr><td>2.77 or 2.771 or 2.7709</td><td>0.36 or 0.362</td></tr><tr><td>2.72 or 2.716 or 2.7160</td><td>0.49 or 0.491</td></tr><tr><td>2.69 or 2.690 or 2.6902</td><td>0.57 or 0.568</td></tr><tr><td>2.67 or 2.672 or 2.6721</td><td>0.61 or 0.613</td></tr></table> All first column correct – either 2 and 3 decimal places or 3 and 4 decimal places. All second column correct. Allow a mixture of decimal places. Uncertainties in $\lg (V/V)$ from ± 0.02 to ± 0.01. Allow more than one significant figure.	2.80 or 2.799 or 2.7993	0.28 or 0.279	2.79 or 2.792 or 2.7924	0.30 or 0.301	2.77 or 2.771 or 2.7709	0.36 or 0.362	2.72 or 2.716 or 2.7160	0.49 or 0.491	2.69 or 2.690 or 2.6902	0.57 or 0.568	2.67 or 2.672 or 2.6721	0.61 or 0.613	1 1 1
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(c) (i)	Six points plotted correctly. Must be within half a small square. No “blobs”.	1												
	All error bars in $\lg (V/V)$ 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												
(ii)	Line of best fit drawn. Line must not be drawn from top point to bottom point unless points are balanced. Upper end of line should pass between (2.694, 0.55) and (2.700, 0.55) and lower end of line should pass between (2.770, 0.35) and (2.776, 0.35).	1												
	Worst acceptable line drawn correctly. Steepest or shallowest possible line that passes through <u>all</u> the error bars. Mark scored only if all error bars are plotted.	1												
(iii)	Gradient determined with a triangle that is at least half the length of the drawn line. Read-offs must be accurate to half a small square. Gradient must be negative.	1												
	Method of determining absolute uncertainty. uncertainty = gradient of line of best fit – gradient of worst acceptable line <i>or</i> uncertainty = $\frac{1}{2}$ (steepest worst line gradient – shallowest worst line gradient)	1												

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(iv)	y-intercept determined by substitution into $y = mx + c$. Read-offs must be accurate to half a small square.	1
	Method of determining absolute uncertainty. 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) No ECF from false origin method.	1
(d)	Use of $p = 10^{\text{answer to 2(c)(iv)}}$ or $\lg p = \text{answer to 2(c)(iv)}$	1
	$q = \text{gradient}$ <u>and</u> in the range -2.50 to -2.70 <u>and</u> given to 2 or 3 s.f.	1
(e)	Use of $V = p \times 950^q$ or $\lg V = q \lg 950 + \lg p$ or $\lg V = q \lg 950 + \text{y-intercept}$ Correct substitution of numbers must be seen to give V.	1

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	Method to ensure that copper tube is vertical, e.g. set square, spirit level, plumb line.	1
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	Method to <u>measure B</u> , e.g. Hall probe.	1
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(d) (i)	$E = 1/\text{y-intercept}$ <u>and</u> given to 2 or 3 s.f.	1
	$Y = \frac{1}{E \times \text{gradient}} \text{ or } \frac{y - \text{intercept}}{\text{gradient}}$ Y in the range $(0.90 \text{ to } 1.20) \times 10^{-3} \text{ F}$. Appropriate unit required. Correct substitution of numbers must be seen.	1
(ii)	Percentage uncertainty in Y $= \left(\frac{\Delta m}{m} + \frac{\Delta c}{c} \right) \times 100 \text{ or}$ $= \left(\frac{\Delta m}{m} + \frac{\Delta E}{E} \right) \times 100 \text{ or}$ $= \frac{\Delta Y}{Y} \times 100$ Maximum/minimum methods: $\text{max } Y = \frac{1}{\text{min } E \times \text{min gradient}} = \frac{\text{max } y - \text{intercept}}{\text{min gradient}}$ $\text{min } Y = \frac{1}{\text{max } E \times \text{max gradient}} = \frac{\text{min } y - \text{intercept}}{\text{max gradient}}$	1