
PHYSICS

9702/51

Paper 5 Planning, Analysis and Evaluation

October/November 2017

MARK SCHEME

Maximum Mark: 30

Published

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Question	Answer	Marks
1	Defining the problem	
	d is the independent variable and R is the dependent variable or vary d and measure R	1
	keep intensity/power of light source <u>constant</u>	1
	Methods of data collection	
	labelled diagram showing a light source fixed above container of water with the labelled LDR positioned in the beaker	1
	correct circuit diagram to measure R , e.g. V and I methods or ohmmeter	1
	method to determine R , e.g. $R = \frac{\text{p.d. across LDR}}{\text{current}}$ or read off ohmmeter	1
	method to determine d , e.g. use a ruler or drawn labelled vertical ruler adjacent to container <u>with d indicated</u>	1
	Method of analysis	
	plots a graph of R against d^2	1
	relationship valid if a straight line produced <u>passing through the origin</u>	1
	$K = \frac{4\pi}{\text{gradient}}$	1

Question	Answer	Marks
1	Additional detail including safety considerations	Max. 6
D1	dark glasses to prevent damage to eyes due to light source or do not look directly at light source or do not touch <u>hot</u> lamp/use gloves to position <u>hot</u> lamp/ <u>heat-proof</u> gloves to position lamp	
D2	dark room or shielding LDR (so as to avoid light from other sources)	
D3	use high intensity lamp or collimated beam or laser	
D4	<u>method</u> described to check that current in light source is constant, e.g. use an ammeter and variable resistor / variable power supply	
D5	keep position of light source constant or distance between light source and LDR constant	
D6	light source is placed close to water surface to increase intensity/reduce reflections or light source is placed further away to make it more directional	
D7	use tall container <u>to give a wide range of d or R</u> or <u>to reduce uncertainties</u> or use a wide container <u>to reduce reflections</u>	
D8	method to position ruler vertically to measure d described e.g. use a set square/spirit level	
D9	use of horizontal fiducial mark from ruler to meniscus or middle of LDR, e.g. pin or d = reading on rule at surface – reading at top of LDR	
D10	ensure that the electrical connections/wire to the LDR are waterproof	

Question	Answer	Marks							
2(a)	$\text{gradient} = -\frac{2mg}{s}$ $y\text{-intercept} = mg$	1							
2(b)	<table><tr><td>$(T_1 - T_2)/N$</td></tr><tr><td>5.5 ± 0.2</td></tr><tr><td>4.6 ± 0.2</td></tr><tr><td>3.6 ± 0.2</td></tr><tr><td>2.8 ± 0.2</td></tr><tr><td>1.9 ± 0.2</td></tr><tr><td>1.3 ± 0.2</td></tr></table> First mark for column heading and values of $(T_1 - T_2)/N$. Second mark for all uncertainties = ± 0.2.	$(T_1 - T_2)/N$	5.5 ± 0.2	4.6 ± 0.2	3.6 ± 0.2	2.8 ± 0.2	1.9 ± 0.2	1.3 ± 0.2	2
$(T_1 - T_2)/N$									
5.5 ± 0.2									
4.6 ± 0.2									
3.6 ± 0.2									
2.8 ± 0.2									
1.9 ± 0.2									
1.3 ± 0.2									
2(c)(i)	Six points plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square	1							
	Error bars in P plotted correctly. All error bars to be plotted. 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. Must not be drawn from top point to bottom point. If points are plotted correctly then upper end of line should pass between (0.125, 5.0) and (0.140, 5.0) and lower end of line should pass between (0.360, 1.5) and (0.380, 1.5).	1
	Worst acceptable line drawn correctly (steepest or shallowest possible line). All error bars must be plotted.	1
2(c)(iii)	Gradient determined with a triangle that is at least half the length of the drawn line. Must be negative.	1
	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 from substitution into $y = mx + c$.	1
	y-intercept determined using gradient of worst acceptable line. 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

Question	Answer	Marks
2(d)(i)	m determined using candidate's y -intercept and correct units for m and s . $m = \frac{y\text{-intercept}}{g} = \frac{y\text{-intercept}}{9.81}$	1
	s determined using candidate's gradient and m <u>and</u> s given to 2 or 3 significant figures. Correct substitution of numbers must be seen. $s = \frac{-2mg}{\text{gradient}} = \frac{-2 \times y\text{-intercept}}{\text{gradient}}$	1
2(d)(ii)	percentage uncertainty in m = percentage uncertainty in y -intercept	1
	percentage uncertainty in s = percentage uncertainty in gradient + percentage uncertainty in y -intercept or percentage uncertainty in s = percentage uncertainty in gradient + percentage uncertainty m Maximum/minimum methods: $\text{max } s = \frac{-2 \times \text{max } y\text{-intercept}}{\text{min gradient}} \text{ or } \frac{-2g \times \text{max } m}{\text{min gradient}}$ $\text{min } s = \frac{-2 \times \text{min } y\text{-intercept}}{\text{max gradient}} \text{ or } \frac{-2g \times \text{min } m}{\text{max gradient}}$ Correct substitution of numbers must be seen.	1

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Question	Answer	Marks
1	Defining the problem	
	x is the independent variable and V is the dependent variable or vary x and measure V	1
	keep <u>current</u> (in the coil P) <u>constant</u>	1
	Methods of data collection	
	labelled diagram showing both coils supported	1
	two correct circuit diagrams for coil P <u>and</u> coil Q: power supply connected to one coil <u>and</u> voltmeter/c.r.o. connected to other coil	1
	method to determine x, e.g. use a ruler or drawn labelled horizontal ruler adjacent to coils <u>with x indicated</u>	1
	method to measure x from centre of coil P to centre of coil Q, e.g. measure width of (each) coil and divide by 2 and add to separation of coils	1
	Method of analysis	
	plots a graph of $\ln V$ against x [or $\log V$ against x etc.]	1
	relationship valid if a straight line produced	1
	$k = -\text{gradient}$	1

Question	Answer	Marks
	Additional detail including safety considerations	Max. 6
	D1 do not touch <u>hot</u> coil/use gloves to position <u>hot</u> coil/ <u>heat-proof</u> gloves to position coil	
	D2 use large current/number of turns/iron core (to produce large magnetic field/induced e.m.f.)	
	D3 use high frequency (to produce larger induced e.m.f.)	
	D4 use an a.c. power supply or signal generator (connected to coil P)	
	D5 keep the number of <u>turns</u> (on each coil) <u>constant</u> /frequency <u>constant</u>	
	D6 method described to check that current is constant, e.g. use an ammeter and variable resistor/variable power supply	
	D7 repeat measurements of x for <u>different</u> parts of the coil <u>and</u> average	
	D8 method to position ruler horizontally to measure x described e.g. use a spirit level or same height from bench at both ends	
	D9 method to keep coils parallel/co-axial e.g. adjust coil Q until maximum reading or use set square to ensure that coils are at right angles to the axis	
	D10 $\ln V = -kx + \ln V_0$	

Question	Answer	Marks														
2(a)	$\text{gradient} = \frac{4\mu L^2 f^2}{g}$	1														
2(b)	<table><tr><th>M / g</th><th>$\frac{1}{n^2}$</th></tr><tr><td>850 ± 85 (90)</td><td>0.1 or 0.11 or 0.111 or 0.1111</td></tr><tr><td>500 ± 50</td><td>0.06 or 0.063 or 0.0625</td></tr><tr><td>300 ± 30</td><td>0.04 or 0.040 or 0.0400</td></tr><tr><td>200 ± 20</td><td>0.03 or 0.028 or 0.0278</td></tr><tr><td>150 ± 15 (20)</td><td>0.02 or 0.020 or 0.0204</td></tr><tr><td>100 ± 10</td><td>0.02 or 0.016 or 0.0156</td></tr></table> First mark for uncertainties in first column correct. Second mark for all second column correct.	M / g	$\frac{1}{n^2}$	850 ± 85 (90)	0.1 or 0.11 or 0.111 or 0.1111	500 ± 50	0.06 or 0.063 or 0.0625	300 ± 30	0.04 or 0.040 or 0.0400	200 ± 20	0.03 or 0.028 or 0.0278	150 ± 15 (20)	0.02 or 0.020 or 0.0204	100 ± 10	0.02 or 0.016 or 0.0156	2
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2(c)(i)	Six points plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	1														
	Error bars in M plotted correctly. All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.	1														
2(c)(ii)	Line of best fit drawn. Line must not pass through plotted point (0.11, 850) or (0.111, 850). If points are plotted correctly then lower end of line should pass between (0.032, 250) and (0.036, 250) and upper end of line should pass between (0.098, 800) and (0.104, 800).	1														
	Worst acceptable line drawn (steepest or shallowest possible line). All error bars must be plotted.	1														

Question	Answer	Marks
2(c)(iii)	Gradient determined with a triangle that is at least half the length of the drawn line.	1
	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(d)(i)	μ determined correctly using gradient.	1
	$\mu = \frac{9.81}{4 \times 120^2 \times 1.54^2} \times \text{gradient}$ $\mu = 7.18123 \times 10^{-5} \times \text{gradient}$	
	μ determined using gradient and given to 2 or 3 significant figures.	1
	μ determined using gradient and correct unit g m^{-1} and in the range 0.560–0.630 (g m^{-1}).	1

Question	Answer	Marks
2(d)(ii)	Percentage uncertainty in μ. $\% \text{ uncertainty} = \left(2 \times \frac{0.01}{1.54} + 2 \times \frac{5}{120} + \frac{\Delta \text{gradient}}{\text{gradient}} \right) \times 100$ $\% \text{ uncertainty} = 9.63\% + \frac{\Delta \text{gradient}}{\text{gradient}} \times 100$ Maximum/minimum methods: $\text{max } \mu = \frac{9.81 \times \text{max gradient}}{4 \times 115^2 \times 1.53^2}$ $\text{min } \mu = \frac{9.81 \times \text{min gradient}}{4 \times 125^2 \times 1.55^2}$ Correct substitution of numbers must be seen.	1

Question	Answer	Marks
2(e)	M determined correctly using μ from (d)(i). $M = \frac{180^2 \times 1.54^2 \times (\text{d})(\text{i})}{9.81 \times 1000} = 7.833 \times (\text{d})(\text{i})$ Correct substitution of numbers must be seen.	1
	Absolute uncertainty determined. $\% \text{ uncertainty} = \left(2 \times \frac{0.01}{1.54} + 2 \times \frac{5}{180} \right) \times 100 + (\text{d})(\text{ii}) = 6.9\% + (\text{d})(\text{ii})$ Correct substitution of numbers must be seen. Maximum/minimum methods: $\max M = \frac{(4 \times) 185^2 \times 1.55^2 \times \max(\text{d})(\text{i})}{(4 \times) 9.81 \times 1000} = 8.382 \times \max(\text{d})(\text{i})$ $\min M = \frac{(4 \times) 175^2 \times 1.53^2 \times \min(\text{d})(\text{i})}{(4 \times) 9.81 \times 1000} = 7.308 \times \min(\text{d})(\text{i})$	1

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D7	use tall container <u>to give a wide range of d or R</u> or <u>to reduce uncertainties</u> or use a wide container <u>to reduce reflections</u>	
D8	method to position ruler vertically to measure d described e.g. use a set square/spirit level	
D9	use of horizontal fiducial mark from ruler to meniscus or middle of LDR, e.g. pin or d = reading on rule at surface – reading at top of LDR	
D10	ensure that the electrical connections/wire to the LDR are waterproof	

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	Worst acceptable line drawn correctly (steepest or shallowest possible line). All error bars must be plotted.	1
2(c)(iii)	Gradient determined with a triangle that is at least half the length of the drawn line. Must be negative.	1
	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 from substitution into $y = mx + c$.	1
	y-intercept determined using gradient of worst acceptable line. 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

Question	Answer	Marks
2(d)(i)	m determined using candidate's y -intercept and correct units for m and s . $m = \frac{y\text{-intercept}}{g} = \frac{y\text{-intercept}}{9.81}$	1
	s determined using candidate's gradient and m <u>and</u> s given to 2 or 3 significant figures. Correct substitution of numbers must be seen. $s = \frac{-2mg}{\text{gradient}} = \frac{-2 \times y\text{-intercept}}{\text{gradient}}$	1
2(d)(ii)	percentage uncertainty in m = percentage uncertainty in y -intercept	1
	percentage uncertainty in s = percentage uncertainty in gradient + percentage uncertainty in y -intercept or percentage uncertainty in s = percentage uncertainty in gradient + percentage uncertainty m Maximum/minimum methods: $\text{max } s = \frac{-2 \times \text{max } y\text{-intercept}}{\text{min gradient}} \text{ or } \frac{-2g \times \text{max } m}{\text{min gradient}}$ $\text{min } s = \frac{-2 \times \text{min } y\text{-intercept}}{\text{max gradient}} \text{ or } \frac{-2g \times \text{min } m}{\text{max gradient}}$ Correct substitution of numbers must be seen.	1