

Cambridge International Examinations Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS

9702/51 May/June 2016

Paper 5 Planning, Analysis and Evaluation MARK SCHEME Maximum Mark: 30

Published

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International Examinations

P	age 2	Mark Scheme Cambridge International AS/A Level – May/June 2016	Syllabus 9702	Paper 51			
Qu	estion	1 Planning (15 marks)					
Defining the problem (2 marks)							
Ρ	λ is th	e independent variable, or vary λ .		[1]			
Ρ	V is th	e dependent variable, or measure <i>V</i> .		[1]			
Ме	thods	of data collection (4 marks)					
М		t diagram showing <u>d.c. power supply</u> in series with diode (correct sym od to measure potential difference across diode. Circuit must be corre	,) and [1]			
М	Instru resiste	ment to change p.d. across LED e.g. variable power supply/potential o or.	divider/varia	ble [1]			
Μ	Recor	d wavelength of light of LED from data sheet or use Young's slits/diffr	action gratir	ng. [1]			
Μ	(Slow proce	y) increase potential difference across LED until LED (just) emits light dure).	t (or reverse	[1]			
Ме	thod o	f analysis (3 marks)					
А	Plot a	graph of Ig V against Ig λ (allow natural logs). Allow Ig λ against Ig V	•	[1]			
А	<i>n</i> = gr	adient		[1]			
А	<i>k</i> = 10	∽intercept		[1]			
Ad	ditiona	l detail (6 marks)					
Re	levant p	points might include:		[6]			
1	Use o	f a <u>protective</u> resistor (can be shown on the diagram).					
2	Polari	ty of LED correct in <u>circuit diagram</u> .					
3	Instru	ment to determine when LED just lights e.g. light meter/detector, LDR					
4	Metho	d to use light detector/LDR to determine point at which LED emits light	nt.				
5		ssion that gives λ (symbols need to defined) from experimental deterr ength of light, e.g. Young's slits/diffraction grating.	nination of				
6	Perfo	m experiment in a dark room/LED in tube.					
7	Relati	onship is valid if graph is a straight line.					
8	lgV =	$n \lg \lambda + \lg k$					
9	Repe	at V and average for the same λ or LED.					
Do	not allo	w vague computer methods.					

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Question 2 Analysis, conclusions and evaluation (15 marks)

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4LF}{\pi E}$	
(b)	T1	$\frac{1}{d^2}$ / 10 ⁶ m ⁻²	
	T2	13 or 12.8 9.8 or 9.77 6.9 or 6.93 4.7 or 4.73 3.2 or 3.19 1.9 or 1.93	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 2 to ± 0.1	Allow more than one significant figure.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Must be accurate to less than half a small square.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (3.2, 3.0) and (3.6, 3.0) and upper end of line should pass between (11.2, 10.0) and (11.6, 10.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Lines must cross. Mark scored only if error bars are plotted.
(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 9×10^{-10} .)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty Difference in worst gradient and gradient.
(d) (i)	C2	$\frac{4LF}{\pi \times \text{gradient}} = \frac{60.479}{\text{gradient}}$	Do not penalise POT. (Should be about 7×10^{10} .)
	C3	Nm ⁻² or Pa	Allow in base units: $kg m^{-1} s^{-2}$.
(ii)	U4	Percentage uncertainty in E	Must be larger than 3%.

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	Mark	Expected Answer	Additional Guidance		
(e)	C4	e in the range 15.5×10^{-3} to 18.0×10^{-3} and given to 2 or 3 s.f.	Allow mm.		

Note $e = \frac{\text{gradient}}{d^2}$ is possible.

Uncertainties in Question 2

Absolute uncertainty in e

(c) (iii) Gradient [U3]

U5

uncertainty = gradient of line of best fit - gradient of worst acceptable line

uncertainty = 1/2 (steepest worst line gradient - shallowest worst line gradient)

percentage uncertainty =
$$\left(\frac{\Delta \text{gradient}}{\text{gradient}} + \frac{0.01}{2.50} + \frac{0.5}{19.0}\right) \times 100 = \left(\frac{\Delta \text{gradient}}{\text{gradient}}\right) \times 100 + 3.03\%$$

max $E = \frac{4 \times \max L \times \max F}{\pi \times \min \text{ gradient}} = \frac{4 \times 2.51 \times 19.5}{\pi \times \min \text{ gradient}} = \frac{62.319}{\min \text{ gradient}}$
min $E = \frac{4 \times \min L \times \min F}{\pi \times \max \text{ gradient}} = \frac{4 \times 2.49 \times 18.5}{\pi \times \max \text{ gradient}} = \frac{58.652}{\max \text{ gradient}}$

(e) [U5]

percentage uncertainty =
$$\left(\frac{0.5}{19.0} + \frac{0.01}{2.50} + 2 \times \left(\frac{0.02}{0.23}\right)\right) \times 100 + \%E = 20.4\% + \%E$$

percentage uncertainty = $\left(\frac{\Delta \text{gradient}}{\text{gradient}} + 2 \times \left(\frac{0.02}{0.23}\right)\right) \times 100$

 $max e = \frac{max \text{ gradient}}{d_{min}^2}$ $max e = \frac{4 \times L_{max} \times F_{max}}{\pi \times E_{min} \times d_{min}^2}$ $min e = \frac{min \text{ gradient}}{d_{max}^2}$ $min e = \frac{4 \times L_{min} \times F_{min}}{\pi \times E_{max} \times d_{max}^2}$